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FULL-SCALE INCINERATION SYSTEM DEMONSTRATION AT THE NAVAL CONSTRUCTION BATTALION CENTER, GULFPORT, MISSISSIPPI - VOL I: PROJECT SUMMARY

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This technical report is divided into eight volumes. This portion of the report comprises Volume 1, Project Summary. This volume describes the project as a whole. The overall goal of the project was to determine the reliability and cost-effectiveness of a 100 tons/day rotary kiln incinerator in processing soil contaminated with dioxins and other hazardous constitutents of Herbicide Orange. The demonstration project consisted of three phases: 1) demonstation of the effectiveness of the incinerator to process the soil, 2) demonstration of the ability of the incinerator to meet Resource Conservation and Recovery Act requirements (Destruction and Removal Efficiency of 99.9999%), and 3) determination of the cost and reliability of using the incinerator on a long-term basis. This volume provides a general background section, a brief description of the process equipment, and a discussion (with conclusions and recommendations) of the field operations from six of the other volumes. The volume not discussed in this report is Volume VIII, Delisting.

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EXECUTIVE SUMMARY

The Naval Construction Battalion Center (NCBC) Demonstration Project was conducted as part of the research test and evaluation phase of the U.S. Air Force Installation Restoration Program and was sponsored by the Air Force Engineering and Services Center (AFESC). The overall goal of the project was to determine the reliability and cost-effectiveness of a 100 tons/day rotary kiln incinerator in processing soil contaminated with dioxins and other hazardous constituents of Herbicide Orange (HO).

The demonstration project consisted of three phases. The first phase, the verification test burn, demonstrated the effectiveness of the 100 tons/day incinerator to process soil contaminated with constituents of Herbicide Orange, in particular 2,3,7,8-tetrachlorinated dibenzo dioxin.

The second phase demonstrated the ability of the incinerator to meet the requirements of the Resource Conservation and Recovery Act (RCRA), which specifies that the incinerator must meet or exceed a Destruction and Removal Efficiency (DRE) of 99.9999%.

The third phase determined the cost and reliability of using the incinerator on a long-term basis.

Five verification test burns were conducted and evaluated for a range of operating conditions. One hundred tons of contaminated soil were processed under a Research, Development, and Demonstration (RD&D) permit issued by the U.S. Environmental Protection Agency (EPA), Region IV, in accordance with the RCRA of 1976, as amended. Soil feed rates ranged between 2.8 and 6.3 tons/hour. Average kiln temperatures for the five test burns varied between 1,355 and 1,645°F. The Secondary Combustion Chamber (SCC) average temperatures for the five test burn varied between 2,097 and 2,174°F. All test burns achieved the AFESC goal that the treated soil polychlorodibenzo-p-dioxin/polychlorodibenzofuran (PCDD/PCDF) congener sum (tetra, penta, hexa) be less than 1.0 part per billion (ppb).

In May 1987, a RCRA Trial Burn was performed to demonstrate the ability of the incinerator to meet the destruction removal efficiency requirement of 99.9999% as specified in 40 CFR 214.

Hexachloroethane (HCE) and 1,2,4-trichlorobenzene (TCB) were used as the two surrogate Principal Organic Hazardous Constituents (POHCs). Clean builders sand was used as a surrogate soil matrix in lieu of native soil.

Three tests were completed at a nominal feed rate of 5.3 tons/h. The surrogate POHC concentration in the sand was nominally 2,500 parts per million (ppm). Destruction and Removal Efficiencies (DRE) of 99.999977, 99.999979, and 99.99997% were demonstrated.

During the third phase of the NCBC Demonstration Project, 1,006 20- by 20-foot plots were excavated from a depth of 3 inches to as much as 51 inches.

The total soil excavated from these plots was approximately 15,000 yd^3. The equipment used in the soil excavation task were a bulldozer, front-end loader, dump truck, asphalt mill (planer), and a track hoe. Air monitoring was performed at all times during excavation to determine movement of contaminated dust offsite. None was measured. Immediately after the excavation of a plot, a bottom-of-hole sample was taken from the plot and shipped to an analytical laboratory for 2,3,7,8-TCDD analysis. If the analytical results showed the 2,3,7,8-TCDD concentration to be less than 1.0 ppb, the plot was considered to be clean. If the results showed the concentration to be 1.0 ppb or greater, the plot was re-excavated.

As the soil was excavated, it was placed in one of three soil storage tents located near the incinerator. A material handler, using a front-end loader, transferred the soil from the storage tents to the weigh hopper/shredder unit where it was weighed, shredded into small pieces, and dropped onto a covered feed conveyor. The covered conveyor belt carried the soil to the feed hopper where the auger fed the soil into the rotary kiln incinerator. The soil in the rotary kiln was subjected to a minimum temperature of 1,450°F for 20 to 40 minutes to volatize the organics. At the outlet of the kiln, the burned solids (ash) fell into a water quench tank,

while the gases and submicron particulate flowed upward through the cyclones and crossover duct to the SCC. The treated soil (ash) was removed from the quench tank and stored in rolloff boxes awaiting laboratory analysis. Upon receipt of satisfactory analytical results, the treated soil was removed from the rolloff boxes and placed back in the field. None of the treated soil required reprocessing.

Maintenance information pertaining to the incineration system was collected daily from the operator's logbook, scheduled and unscheduled maintenance forms, and the Data Acquisition System (DAS) Interlock Summary Sheet. The maintenance and cost data were entered into a computer data base. These data were used to calculate the availability (68%) and cost-effectiveness ($/ton) of the incineration system.

The subcontract for the NCBC Demonstration Project was considered to be a standard cost plus fixed fee (CPFF) subcontract. This type of contract is generally used for research and development projects where there are numerous uncertainties in the scope of work. In March 1988 a revision was made to the Environmental Services Company (ENSCO) subcontract that implemented an incentive for over and above the 8% fixed fee for processing soil at a rate above 2,000 tons/month. The production rate over the next five months increased substantially, peaking at over 3,1000 tons in June. After a couple of months at less that 2,000 tons/month (August and September), the productions rate again rose dramatically to nearly 3,000 tons the last full month of operations (October).

This report is Volume I of VIII. It includes a general background section, a brief description of the process equipment, and a discussion (with conclusions and recommendations) of the field operations from six of the other volumes. The volume not discussed in this report is Volume VIII, Delisting.

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PREFACE

This report was prepared by EG&G Idaho, Inc., P. O. Box 1625, Idaho Falls, ID 83415, under Job Order Number (JON) 2103 9027, for the Air Force Engineering and Services Center, Engineering and Services Laboratory, Tyndall Air Force Base, Florida 32403-6001.

This report covers work done between September 1986 and February 1989. Major Terry Stoddart and Major Michael L. Shelley were the AFESC/RDVS Project Officers.

This report has been reviewed by the Public Affairs Office (PA) and is releasable to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.

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LIST OF ABBREVIATIONS

AFESC	Air Force Engineering and Services Center
ASTM	American Society for Testing of Materials
AWFSO	Automatic Waste Feed Shutoff
BOH	Bottom-of-Hole
BTU	British Thermal Unit
CLP	Contract Laboratory Program
CMP	Configuration Management Plan
CPFF	Cost Plus Fixed Fee
DAS	Data Acquisition System
DLV	Detection Limit Values
DOD	Department of Defense
DOE	Department of Energy
DRE	Destruction and Removal Efficiency
EA	Environmental Assessment
ENSCO	Environmental Services Company
ENT	Effluent Neutralization Tank
EP	Extraction Procedure
EPA	Environmental Protection Agency
FCC	Federal Communication Center
GCMS	Gas Chromatograph Mass Spectrometry
HAFR	High Average Feed Rate
HCE	Hexachlorethane
HO	Herbicide Orange
HRGC	High Resolution Gas Chromatograph
HRMS	High Resolution Mass Spectrometry
HSWA	Hazardous and Solid Waste Amendments
INEL	Idaho National Engineering Laboratory
ITAS	IT Analytical Services
LKOT	Low Kiln Outlet Temperature
LRMS	Low Resolution Mass Spectrometry
LRT	Low Retention Time
M5	EPA Method 5
MM5	EPA Modified Method 5
MTBF	Mean Time Between Failures
NCBC	Naval Construction Battalion Center

ND	Nondetectable
OEHL	Occupation and Environmental Health Laboratory
OSW	Office of Solid Waste
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Byphenyls
PCDD	Polychlorinateddibenzodioxin
PCDF	Polychlorinateddibenzofuran
PMP	Project Management Plan
POHC	Principal Organic Hazardous Constituent
POTW	Publicly Owned Treatment Works
PPB	Parts Per Billion
PPM	Parts Per Million
PPT	Parts Per Trillion
PQL	Positive Quantification Limits
QA/QC	Quality Assurance/Quality Control
QPP	Quality Program Plan
RCRA	Resource Conservation and Recovery Act
RD&D	Research, Development, and Demonstration
RFP	Requests for Proposals
SARE	Soil-to-Ash Removal Efficiencies
SCC	Secondary Combustion Chamber
TCB	1,2,4-trichlorobenzene
TCDD	Tetrachlorodibenzodioxin
TCDF	Tetrachlorodibenzofuran
USAF	U.S. Air Force
VHS/OLM	Vertical Horizontal Spread/Organic Leachate Model
VOST	Volatile Organic Sampling Train
WBS	Work Breakdown Structure

SECTION I
INTRODUCTION

A. OBJECTIVE

The purpose of the Naval Construction Battalion Center (NCBC) Demonstration Project was to demonstrate the reliability and cost-effectiveness of a mobile rotary kiln incinerator in the soil treatment and site restoration of a Herbicide Orange (HO) contaminated site. The mobile waste incineration system, Model MWP-2000, manufactured and operated by Environmental Services Co. of Little Rock, Arkansas (ENSCO) was selected for this Air Force Full-Scale Demonstration. The former HO storage site at the NCBC in Gulfport, Mississippi was the selected location for the demonstration.

The specific goal of this technology demonstration was to reduce the total isomers of tetra-, penta-, and hexachlorodibenzo-p-dioxin and respective isomers of polychlorodibenzofuran to less than one part per billion (ppb). The overall soil treatment goal was to reduce the contaminants to criteria approved by Environmental Protection Agency (EPA) Headquarters, which would facilitate the delisting of tested soil under the auspices of the Resource Conservation and Recovery Act (RCRA) of 1976, as amended by the Hazardous and Solid Waste Amendments (HSWA) of 1984.

The effectiveness of the demonstration was monitored in terms of cost, availability, maintainability, schedule, and the ability to satisfy the current regulations in terms of total site remediation.

B. BACKGROUND

1. Air Force Use of Herbicide Orange

HO is primarily composed of two compounds, 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), and various esters of these two compounds. HO was sprayed as a defoliant in Vietnam during the 1960s. The NCBC served as an interim storage site (5 to 18 months) for drums destined for Southeast Asia until 1970.

In April 1970, the Secretaries of Agriculture, Health, Education, and Welfare, and the Interior jointly announced the suspension of certain uses of 2,4,5-T. This suspension resulted from published studies indicating that 2,4,5-T was a teratogen. Subsequent studies revealed that the teratogenic effects resulted from a toxic contaminant in the 2,4,5-T identified as tetrachlorodibenzodioxin (TCDD). Subsequently, the Department of Defense (DOD) suspended the use of HO, which contained 2,4,5-T. At the time of suspension, the U.S. Air Force (USAF) had an inventory of 1.37 million gallons of HO in South Vietnam and 0.85 million gallons at NCBC. In September 1971, the DOD directed that the HO in South Vietnam be returned to the United States and that the entire 2.22 million gallons be disposed of in an environmentally safe and efficient manner. The 1.37 million gallons were moved to Johnston Island in the central pacific in April 1972. The average concentration of dioxin in the HO was about 2 parts per million (ppm), with the total amount of TCDD in the entire HO stock estimated at 44.1 pounds.

Various disposal techniques for HO were investigated from 1971 to 1974. Of those techniques investigated, only high-temperature incineration was sufficiently developed to warrant further investigation. Therefore, during the summer of 1977, the USAF disposed of 2.22 million gallons of HO by high-temperature incineration at sea. This operation, Project PACER HO, was accomplished under very stringent U.S. EPA ocean dumping permit requirements.

During storage and handling at the storage sites, some of the HO was spilled onto the surrounding soil. The soil was therefore contaminated with dioxin as well as the 2,4-D and 2,4,5-T components. The dioxin contamination on the site ranged from nondetectable to over 640 ppb; the average concentration was estimated at 20 ppb.

2. Overview of Soil Decontamination Program

The USAF plan for disposal of the bulk quantities of HO and the EPA permits for the disposal of the herbicide committed the USAF to a follow-up storage site reclamation and environmental monitoring program. The major objectives of that required program included the following:

1. Determine the magnitude of herbicide, TCDD, and tetrachlorodibenzofuran (TCDF) contamination in and around the former HO storage and test sites.

2. Determine the rate of natural degradation for the phenoxy herbicides (2,4-D and 2,4,5-T), their phenolic degradation products, and TCDD and TCDF in soils of the storage and test sites.

3. Monitor for potential movement of residues from the storage and test sites into adjacent water, sediments, and biological organisms.

4. Recommend managerial techniques for minimizing any impact of the herbicides and dioxin residues on the ecology and human populations near the storage and test sites.

Immediately following the herbicide incineration in 1977, the USAF Occupational and Environmental Health Laboratory (OEHL), which is responsible for routine environmental monitoring, initiated site monitoring studies of chemical residues in soil, silt, water, and biological organisms associated with the former HO storage sites at NCBC and Johnston Island.

To accomplish the goals of returning the former HO storage site at NCBC to full and beneficial use, the Air Force used the technical capabilities of the Department of Energy's (DOE) Idaho National Engineering Laboratory (INEL) and, in particular, EG&G Idaho, a DOE contractor.

In 1985, the Air Force and EG&G Idaho coordinated a site characterization study (Reference 1). The Air Force and EG&G Idaho continued the remediation investigation by coordinating two small-scale projects to demonstrate the feasibility of two different technologies for the removal of dioxin from HO contaminated soil. Although those demonstrations were successful, the technologies were not sufficiently developed to use for full-scale site remediation. When the small-scale projects were completed, the Air Force still had little data to predict the cost and feasibility of remediating large quantities of contaminated soil.

The Air Force, in coordination with EG&G Idaho, proceeded to demonstrate a full-scale demonstration project in which cost and reliability data would be collected during site remediation.

Rotary kiln incineration was chosen as the technology most likely to be cost-effective and reliable. Bids were solicited from a variety of incinerator contractors. Bid evaluation resulted in choosing Environmental Services Company, Pyrotech Division, now known as ENSCO, as the incinerator contractor. While ENSCO provided the equipment and operational personnel for the incinerator and soil excavation, EG&G Idaho provided the expertise in overall project management, EPA permitting, and regulatory compliance. Versar, Inc. provided sampling assistance. IT Analytical Services, Twin Cities Testing, and U.S. Testing provided analytical support.

The full-scale Research, Development, and Demonstration (RD&D) project began in September 1986, when the incinerator was assembled onsite. A verification test burn conducted in December 1986, successfully demonstrated that the incinerator produced no hazardous effluents. In May 1987, a Resource Conservation and Recovery Act (RCRA) Trial Burn successfully demonstrated that the incinerator could achieve the required 99.9999% ("six 9s") Destruction and Removal Efficiency (DRE). Operational testing and site remediation began when EPA Region IV issued the final RD&D permit on November 23, 1987. Testing and remediation continued until November 19, 1988 when the last contaminated soil was processed. The incinerator was decontaminated, disassembled, and removed from the site in February 1989.

3. History of NCBC Site

The former HO storage site is located at the northern end of the NCBC at Gulfport, Mississippi. In the 1940s, the site was designated as a heavy equipment storage area. To accommodate that function, the soil was tilled and mixed with portland cement. The natural precipitation and subsequent drying left a 6-10-inch hard pan layer of cement-stabilized soil.

The boundaries of the former HO storage site were determined through an extensive investigation, using aerial photographs, personal

interviews, and shipping documents. Based upon those data, an extensive sampling and analysis program was developed.

Figure 1 shows the former HO storage area, which was divided into three major sections separated by railroad tracks. Each area was subdivided into 20- by 20-foot plots and sampled for 2,3,7,8-TCDD.

Area A was used for long-term storage of HO from 1970-77. Areas B and C were used in the 1960s for short-term storage of HO awaiting shipment to Southeast Asia. The average length of time that a drum of HO remained at NCBC was approximately 9 months. Contamination of Areas B and C resulted from spillage during handling of the stored HO drums. Because the drums remained in those areas for only a relatively short time, the spread of contamination was less significant than in Area A. Contaminant migration resulted in a pattern of decreasing concentration toward the drainage ditches, which lie at the center of the areas. This was because the drums were stored on the rows near Holtman and Greenwood Avenues in Area B and near Holtman Avenue in Area C. The natural gradient of the site is from those rows toward the drainage ditches.

The total area actually used for HO storage was approximately 16 acres. Because of the storage pattern, however, all of areas A, B, and C were left unusable; those areas comprise approximately 31 acres.

4. Characterization of NCBC Site

In the late 1970s, the Air Force Occupational and Environmental Health Laboratory (OEHL) conducted studies that determined that dioxin was migrating slowly offsite via the drainage ditches. Based upon those studies, the Air Force had sediment filters installed in the drainage ditches to reduce the contaminant migration.

A surface and subsurface soil sampling program was conducted to characterize 2,3,7,8-TCDD concentrations at the HO storage site. Composite sampling was performed in 20- by 20-foot grid plots. Surface concentrations

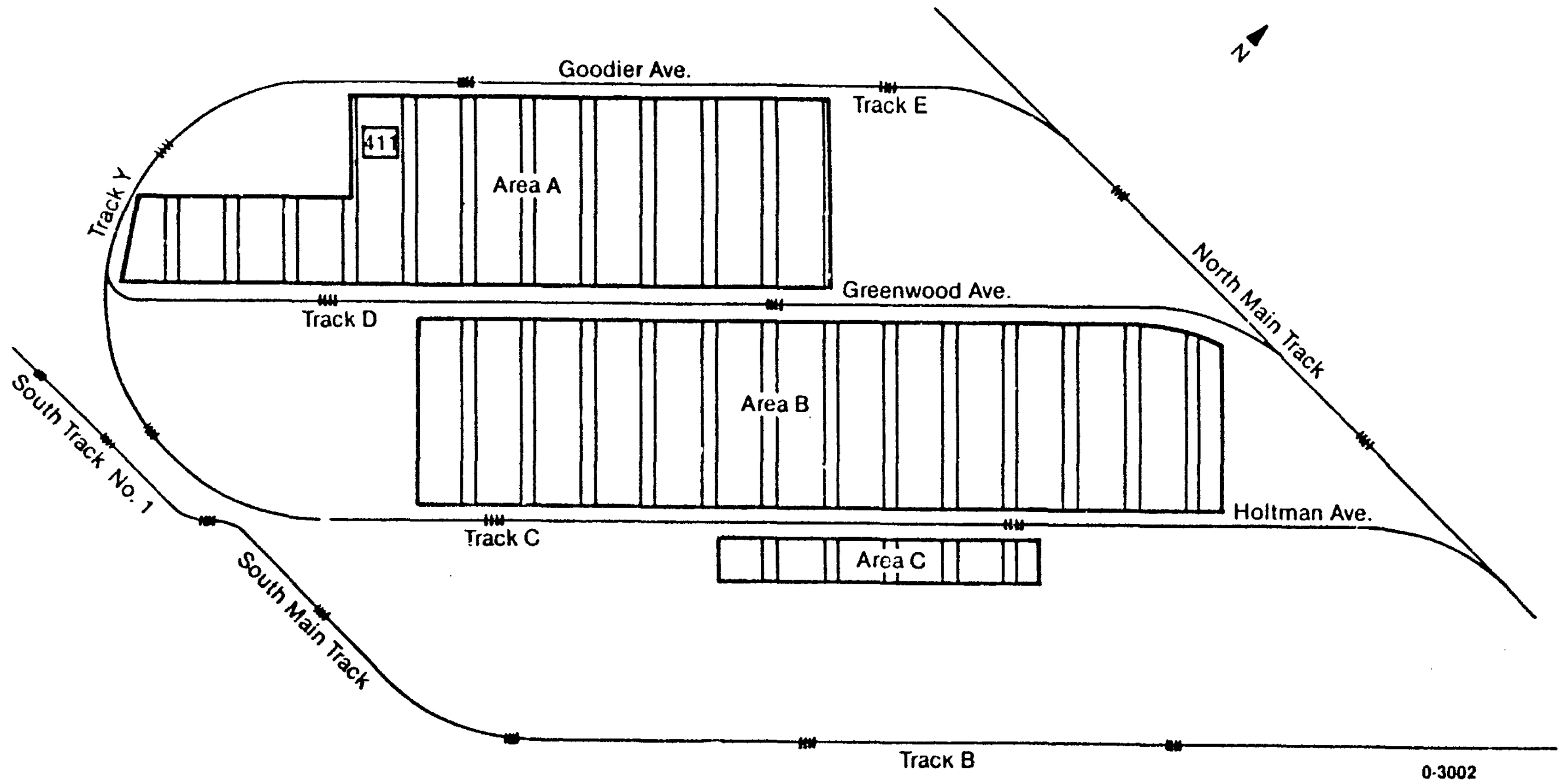

Figure 1. Former HO Storage Site

of 2,3,7,8-TCDD for each grid plot are presented in Reference 1. At the soil surface, the maximum indicated "hot spot" concentration of 2,3,7,8-TCDD was 646 ppb in Zone A. Surface concentrations of 2,3,7,8-TCDD in the contaminated strips in Zones B and C were generally much lower than in Zone A; however, several "hot spots" exceeding 100 ppb were found with a maximum indicated concentration at 344 ppb (Zone B). The maximum indicated 2,3,7,8-TCDD concentration found in the 6-inch-thick cement-stabilized subsurface soil was 998 ppb (Reference 1). The vertical extent of 2,3,7,8-TCDD contamination was shown to sharply decrease below the surface layer. For example, at 2 feet, only five samples of 35 sample locations showed contamination >1 ppb, with a maximum of 12 ppb (Reference 1). At 5 feet, three of 15 subsurface samples showed contamination >1.0, with a maximum of 5.1 ppb.

Because of the cement-stabilized soil, the spilled HO tended to remain close to the surface and did not penetrate deeply into the underlying soil. Additionally, the principal hazard, 2,3,7,8-TCDD, has a very low solubility in water and a very high affinity to soil particles; hence, it did not migrate to deep subsurface layers of soil.

C. SCOPE/APPROACH

This report summarizes the NCBC Demonstration Project highlights, significant issues, and lessons learned that are discussed in detail in the individual reports listed below:

Incinerator Operations
Incinerator Availability
Soil Excavation
Verification Test Burn
RCRA Trial Burn
Project Management/Site Services
Delisting

See Figure 2 for NCBC Demonstration Project Report Breakdown.

NCBC Demonstration Project Report Breakdown

Project Summary Volume 1	Verification Burn Volume 2	Trial Burn Volume 3	Incinerator Operations Volume 4	Incinerator Availability Volume 5	Soil Excavation Volume 6	Project Management & Site Services Volume 7	Delisting Volume 8
Verification burn Trial burns Soil excavation Incinerator operations Incinerator availability Project Management & Site Services Delisting	Site setup description Soil feedstock Incinerator activities Sampling Data results	Site setup description Feedstock Incinerator activities Sampling Data results	Soil processing Decontamination and demodilization	Daily reports Productivity improvements and process changes Data collection during decontamination and demobilization Availability data results	Excavation Soil storage	Plan changes Public relations Subcontractor relations Emergency procedures drills Required site services	Justification and need for delisting Planned approach Sample approach Sample analyis & data results VHS/OLM model Recommendations

Figure 2. NCBC Demonstration Project Report Breakdown

SECTION II
DESCRIPTION OF TECHNOLOGY USED

This section provides a detailed description of the MWP-2000 incinerator system components and operation.

A. GENERAL DESCRIPTION

The ENSCO incinerator system (Mobile Waste Processor--MWP-2000) was designed and fabricated by ENSCO at their White Bluff, Tennessee, manufacturing facility. The MWP-2000 incinerator is a modular system designed to destroy and detoxify solid, semi-solid, and/or liquid wastes. Most of the components of the system are installed on flatbed trailers, platforms, or skids to facilitate the movement of the system from location to location in order to perform onsite cleanup of contaminated sites.

Figure 3 shows an overall view of the MWP-2000 incinerator system as it was installed at the NCBC site. Figure 4 is a system flow schematic. Principal components of the unit are:

- Waste feed system
- Rotary kiln with outlet cyclones
- Secondary Combustion Chamber (SCC)
- Air pollution control train consisting of
  - Effluent neutralization unit
  - Packed tower
  - Ejector scrubber, demister, and stack.

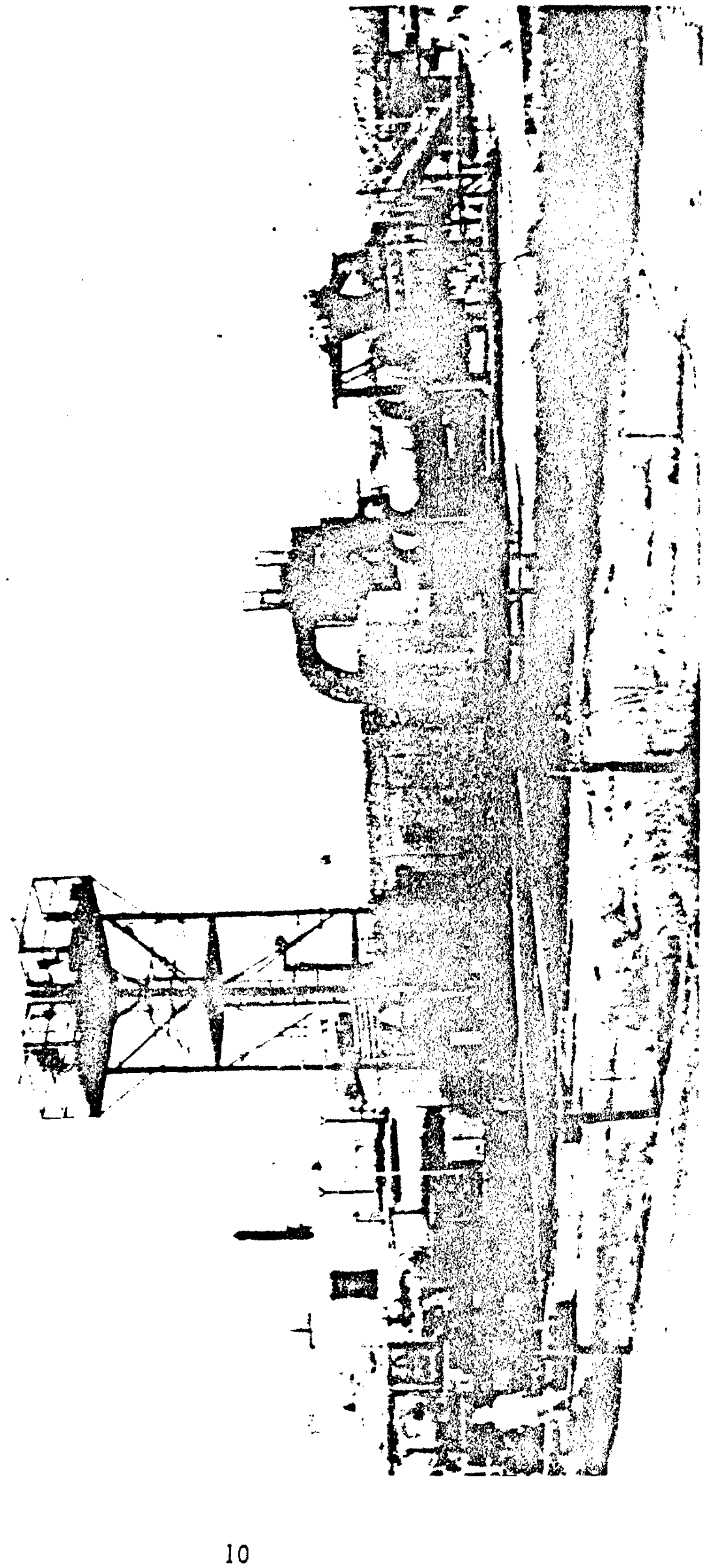

Figure 3. Overall View of MWP-2000 Incinerator System

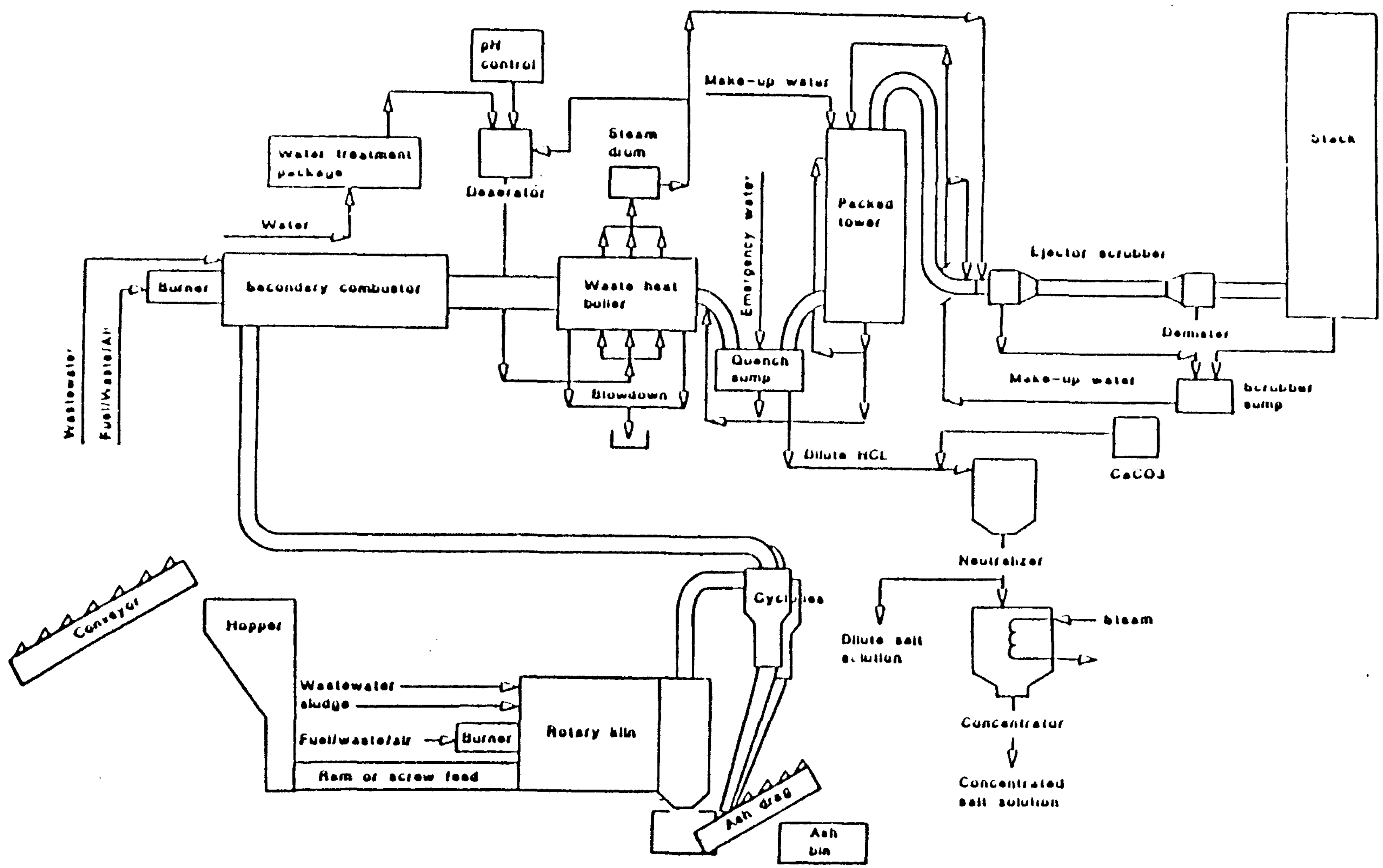

Figure 4. System Flow Schematic

The auxiliary components of the unit are:

- Waste heat boiler and steam drum
- Boiler water treatment unit
- Ash removal unit
- Effluent settling unit
- Effluent holding tanks.

B. PROCESS DESCRIPTION

1. Feed

After soil has been excavated, it is stockpiled near the incinerator. A front-end loader then transfers the soil to a weigh hopper/ shredder unit (Figure 5). The soil is then weighed and shredded into small pieces, which then drop onto a covered feed conveyor that transfers the soil to the feed hopper (Figure 6).

Once the soil falls into the feed hopper, a rotary auger moves the soil into the rotary kiln (Figure 7). Figure 8 shows the 10-inch diameter auger in the process of feeding soil.

2. Primary Incineration

The rotary kiln is primarily designed to burn or detoxify hazardous waste. Detoxification occurs by thermal desorption of organics from the solid waste. Because of the high temperatures, however, the kiln will compost and destroy some of those desorbed organics. Additionally, wastewater and other liquid materials can be processed by injection through nozzles located near the burner.

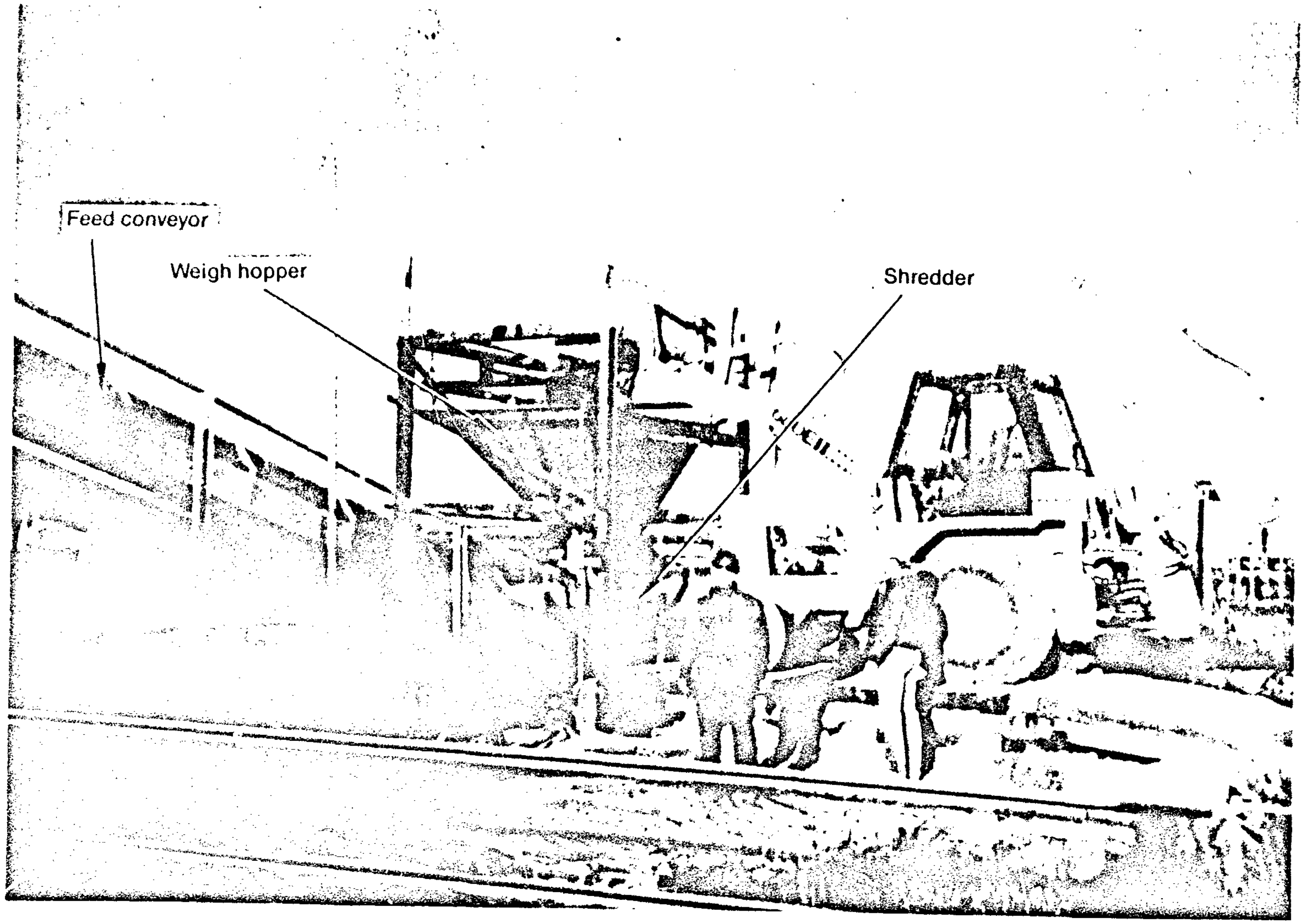

Figure 5. View of Weigh Hopper, Shredder, and Covered Conveyor

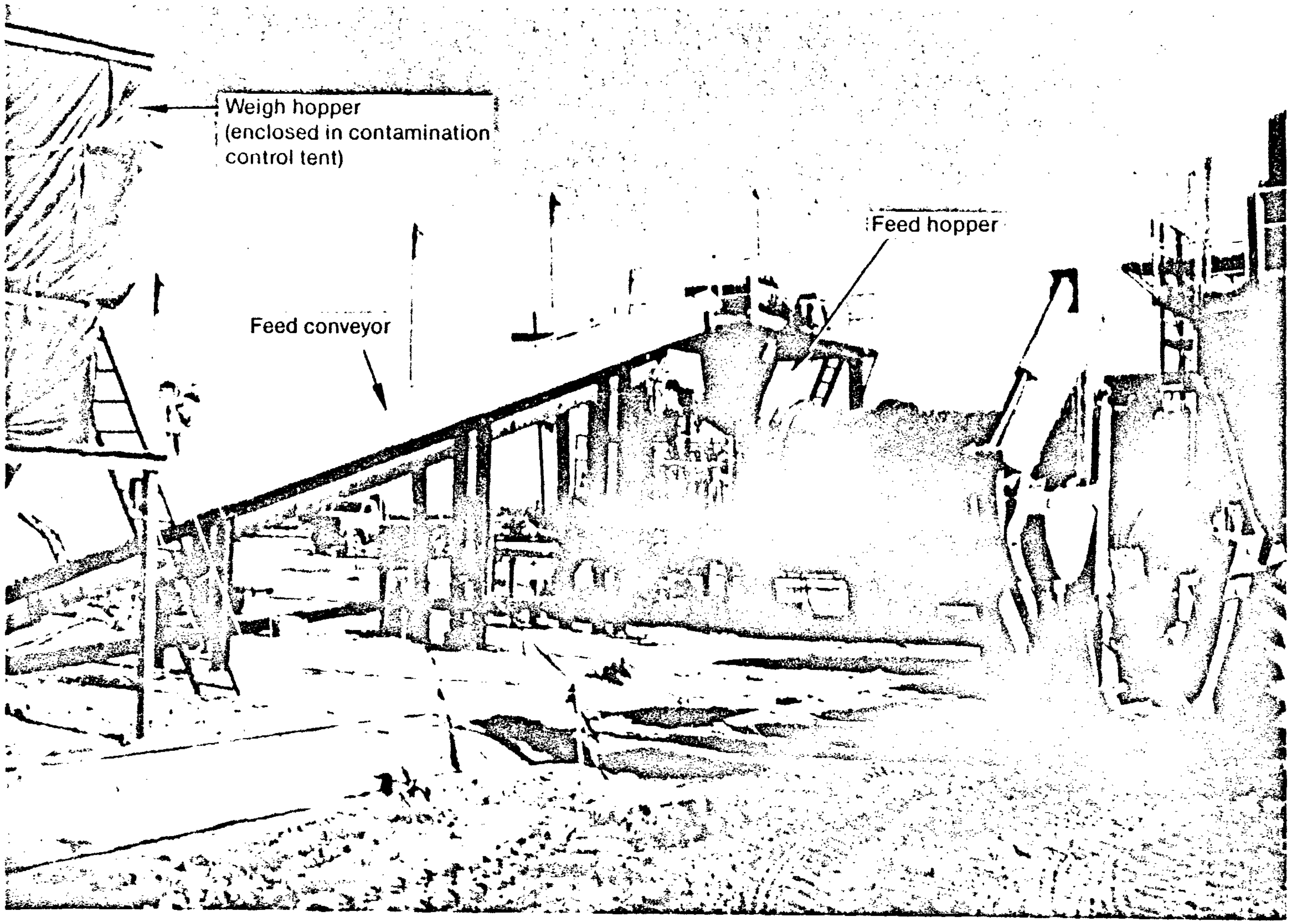

Figure 6. View of Covered Conveyor and Feed Hopper

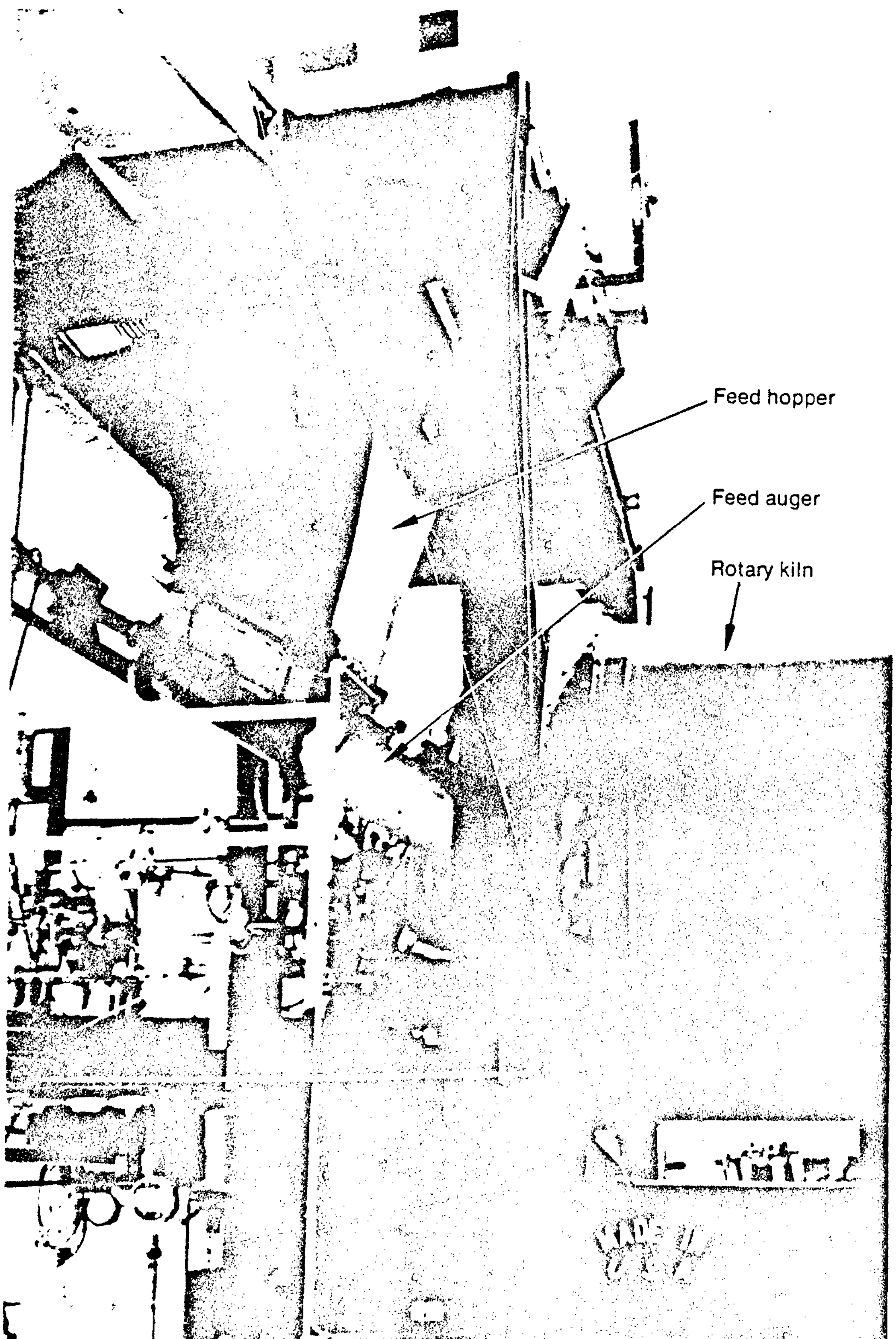

Figure 7. External View of Feed Hopper Bottom and Auger Feed to Kiln

Figure 8. View of Rotary Auger Inside Feed Hopper

The rotary kiln is shown in Figure 9. The kiln is approximately 30 feet long and sits on top of a flatbed tractor trailer. The kiln is declined at approximately 2 degrees and is rotated by a hydraulically powered gear trunnion mechanism (Figure 10).

The kiln burner is rated at 14 million Btu/h and can use a variety of fuels such as fuel oil, propane, or natural gas; this project used natural gas. The outlet gas temperatures typically range from 1,350 to 1,800°F. The solids residence time within the kiln varies from 20 to 40 minutes, depending upon the mass feed rate.

3. Ash Collection

At the gas outlet of the kiln, the solids fall into an ash quench while the gases rise up and flow into the cyclone particle separators. The ash quench is a rectangular water tank into which the processed soil falls. The ash quench and cyclones are shown in Figure 11.

At the bottom of the ash quench is an ash drag conveyor that removes the process ash and places it into an ash bin (Figure 12). During the verification tests burns, a rolloff box, shown in Figure 12 was used. The ash quench also serves as a seal between the process gases and the outside environment.

4. Gas Stream Particulate Separation

The hot process gases flow from the kiln upward to the cyclone separators, which remove the heavy particulate from the gas stream. The removed particulate falls down into the ash quench. Although the incinerator has two cyclones in parallel flow paths, only one cyclone was used for this project.

5. Secondary Combustion

The process gases leave the cyclone and flow into the Secondary Combustion Chamber (SCC), which raises the temperature of the process gas to 2,150°F. This high temperature combusts any remaining organics in the

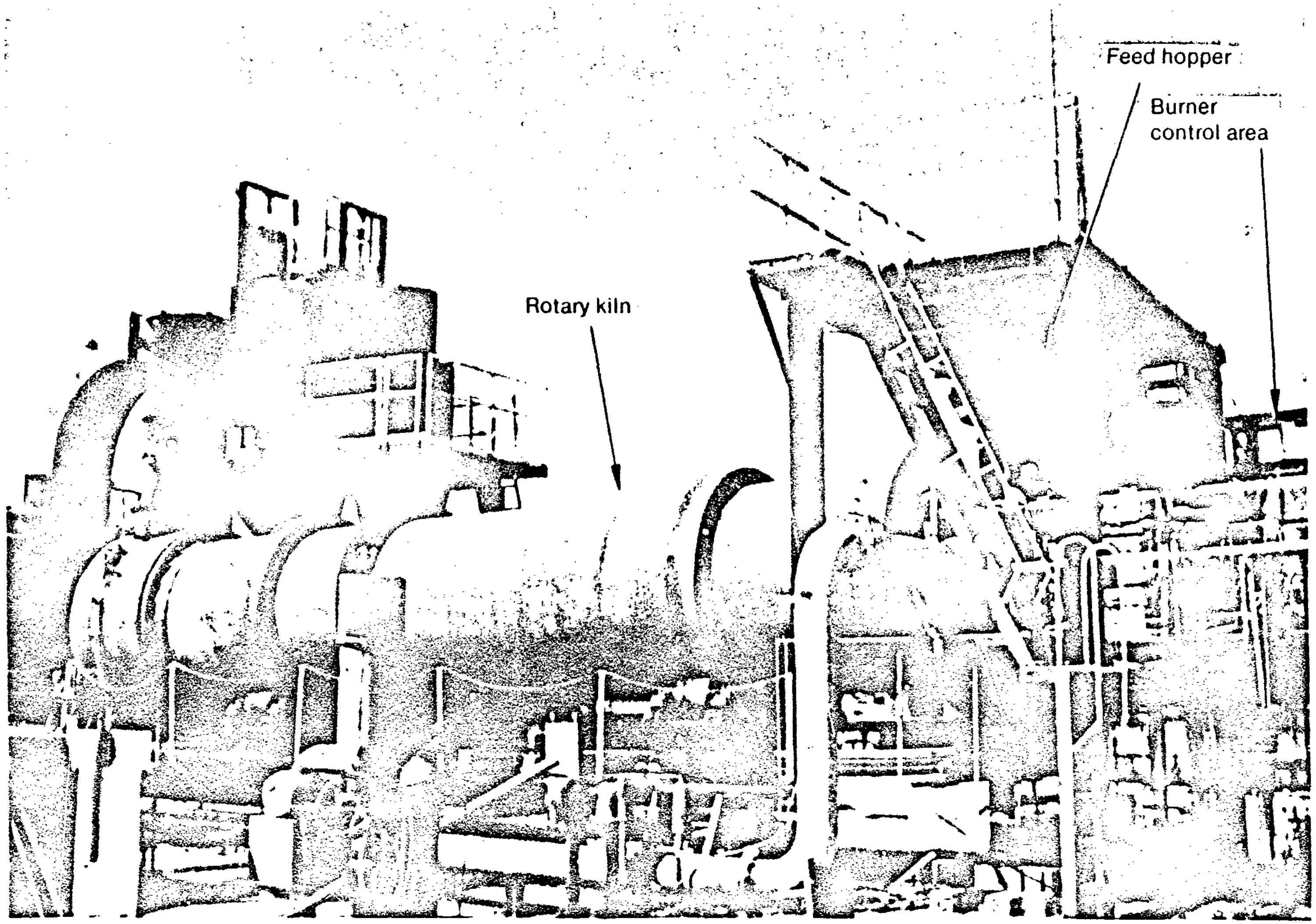

Figure 9. View of Trailer-Mounted Rotary Kiln

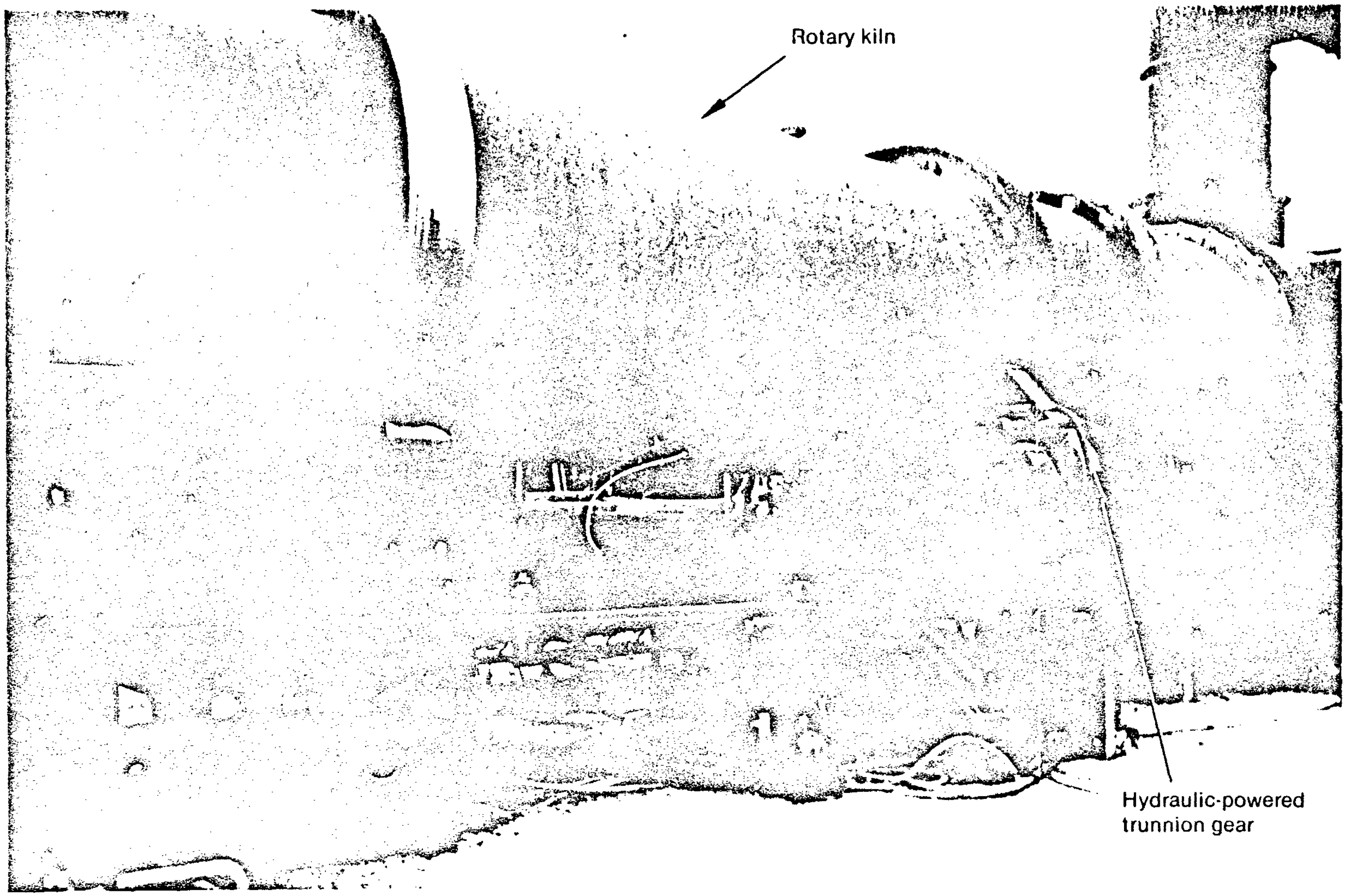

Figure 10. View of Kiln Rotary Drive Mechanism and Trunnion Supports

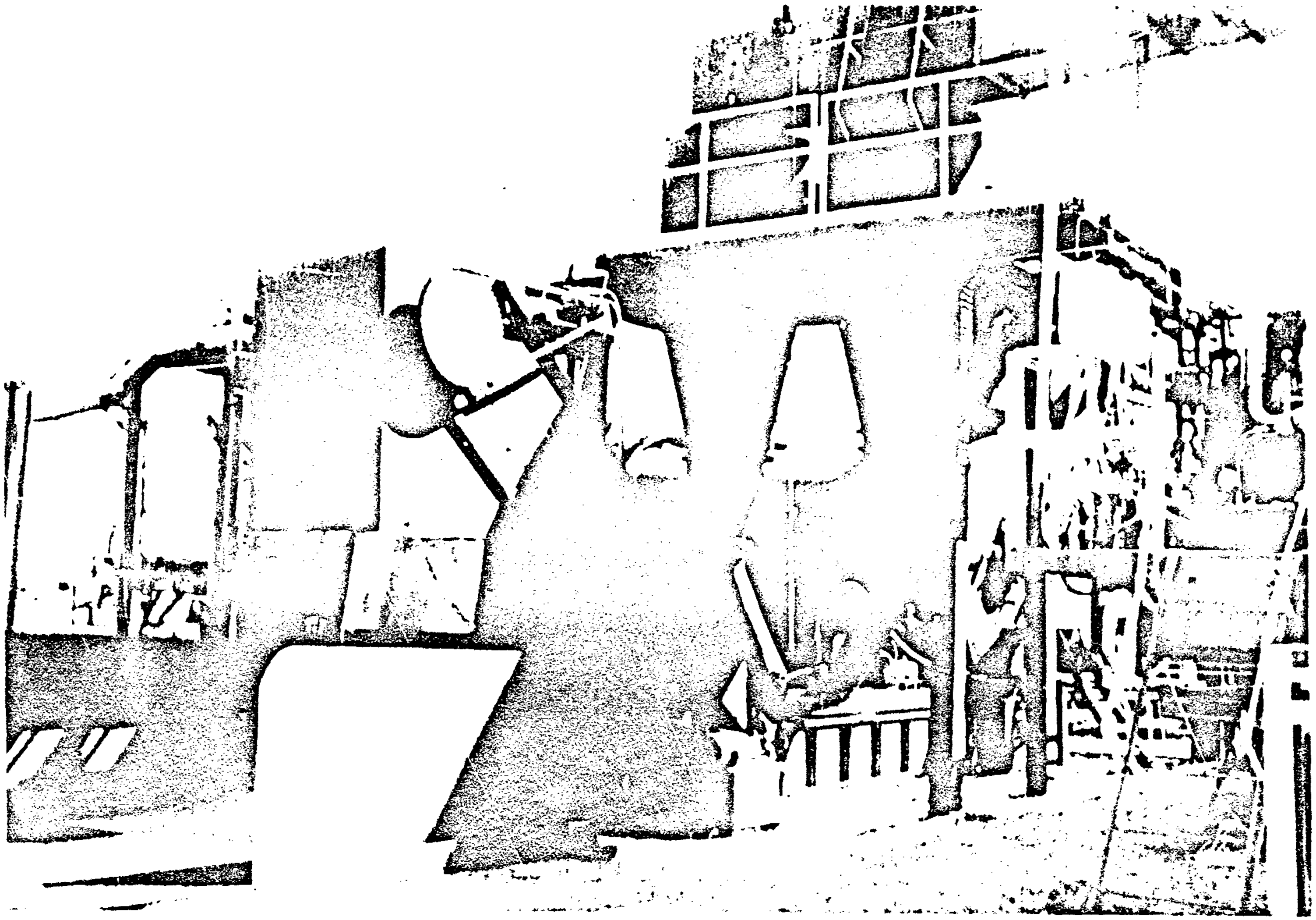

Figure 11. View of Cyclones and Ash Quench

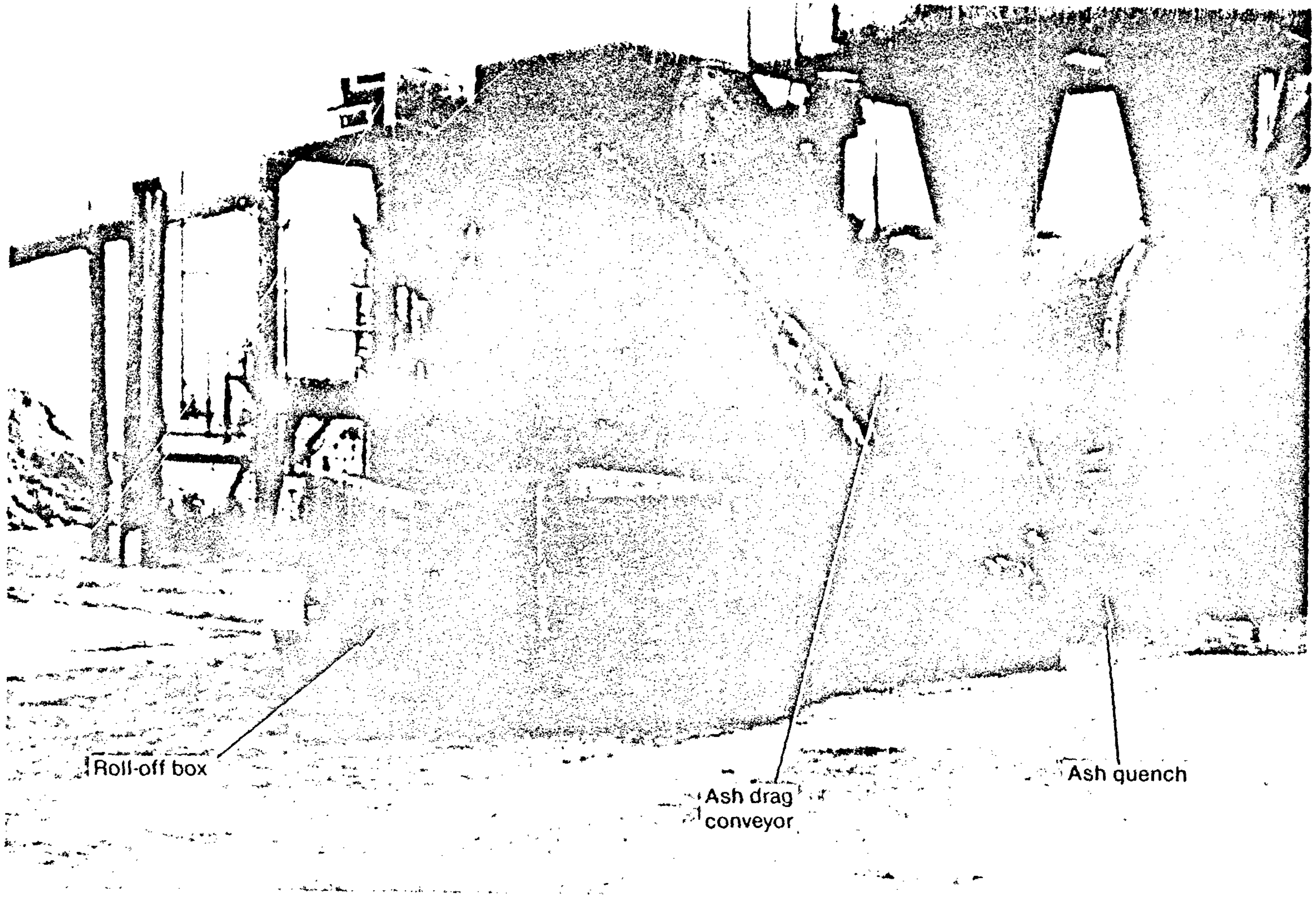

Figure 12. View of Ash Drag and Rolloff Box for Ash Collection

off-gas that were not combusted in the kiln. The SCC is approximately 40 feet long and sits on top of a flatbed tractor trailer (Figure 13).

The SCC is equipped with a vortex burner that is capable of producing approximately 24 million Btu/h by burning natural gas. The burner is capable of using fuel oil or propane in addition to natural gas; however, those fuels were not used during the NCBC Demonstration Project. Similar to the kiln, the SCC can burn liquid organics or contaminated water by direct injection of the liquid into the burner flame.

6. Gas and Liquid Effluent Waste Stream Control

Once the gases leave the SCC, they flow through a waste heat boiler that is designed to produce 250 psig steam by recovering heat from the off-gases. The waste heat boiler and its steam drum are shown in Figure 14. The steam produced in the boiler is used primarily for the ejector scrubber, which is discussed below.

In order to prevent molten and vaporous silica from the processed soil from glassifying onto the inside of the boiler tubes, water spray nozzles were installed between the SCC and the waste heat boiler. The injected water condenses the molten and vaporous silica so that the silica behaves as a particulate rather than as a gas and thus does not plate out onto the boiler tubes.

After the gases leave the boiler, they enter the quench elbow, which is the first device among a series of devices that control effluent gas emissions. The quench elbow, shown to the right of the waste heat boiler in Figure 14, is designed to cool the off-gas by direct water injection. The injected water cools the gases to approximately 170°F, thus allowing the use of fiberglass reinforced plastic for all downstream gas duct work. Additionally, the quench elbow removes some of the acid gases.

The excess water from the quench elbow is collected in the effluent neutralization tank (ENT), which is in front of the quench elbow and packed tower shown in Figure 15. The ENT serves as the central collection point for all of the scrubber water used. The water collected in the ENT is used in a

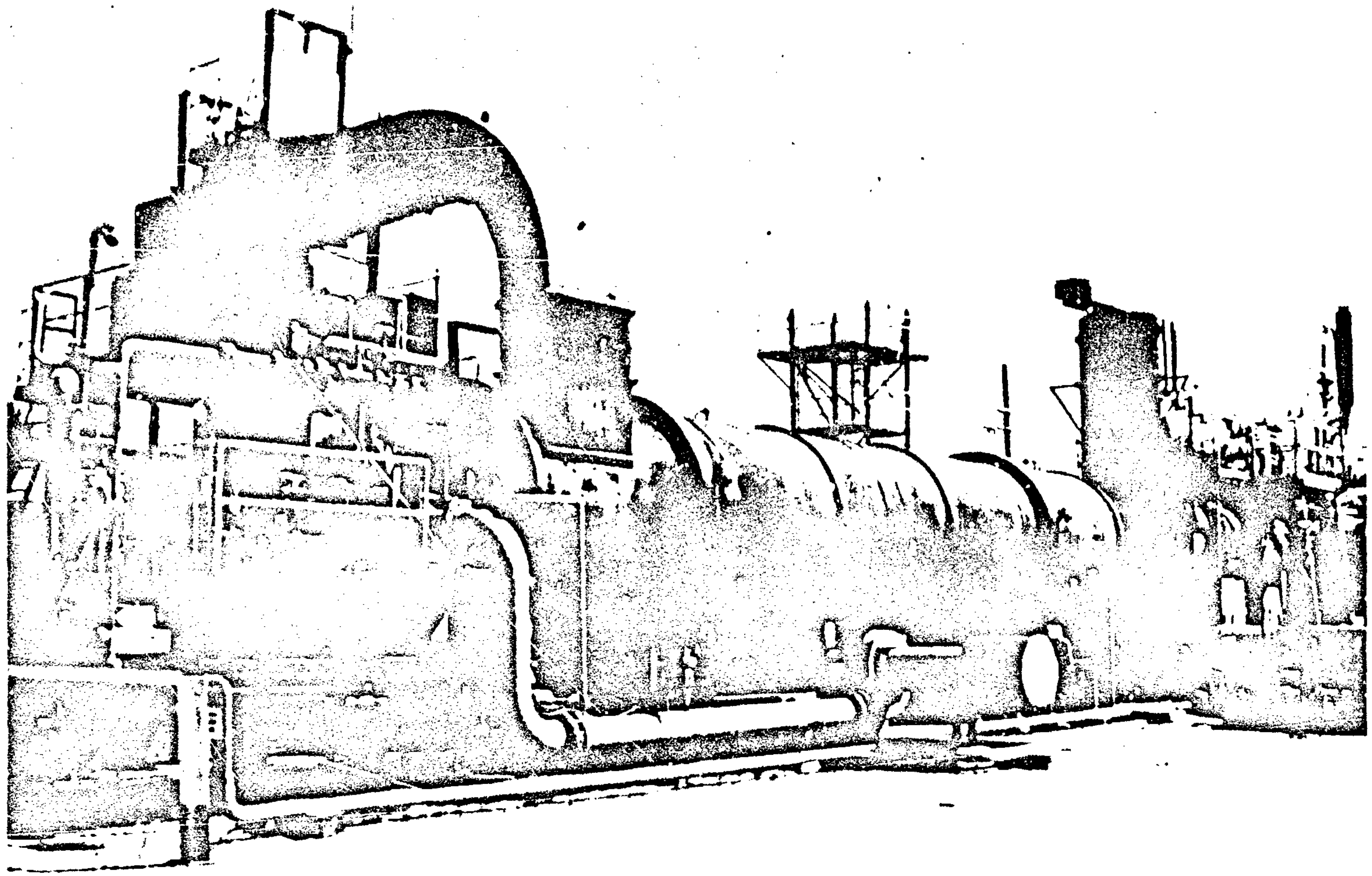

Figure 13. View of Trailer-Mounted Secondary Combustion Chamber

Figure 14. View of Waste Heat Boiler and Steam Drum

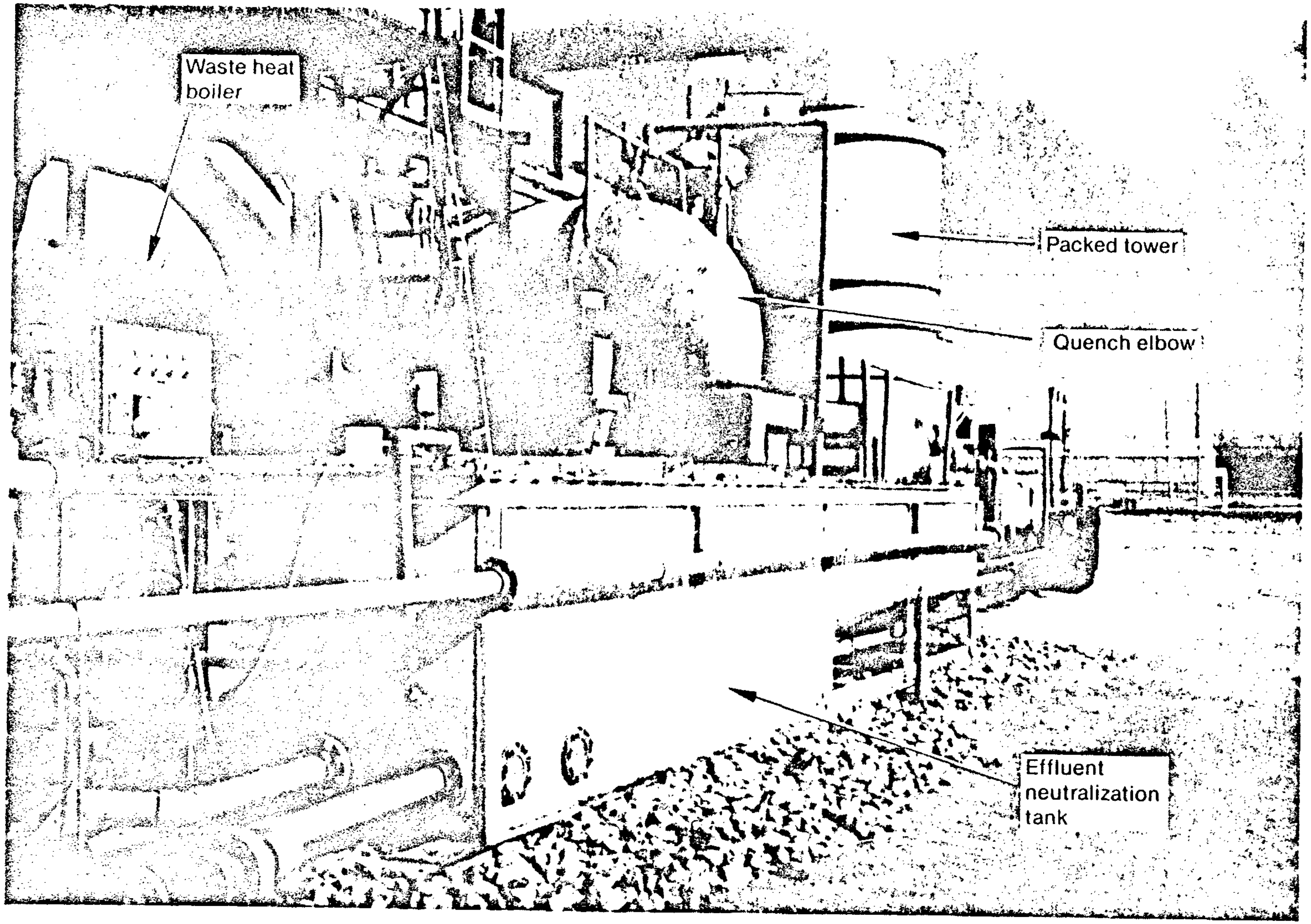

Figure 15. View of Effluent Neutralization Tank with Quench Elbow and Packed Tower

variety of scrubber applications. Caustic (e.g., NaOH) is occasionally added to increase the acid gas scrubbing efficiencies of the scrubbing water.

After the gases are cooled, they flow upward through the packed tower, which is a counter-current flow contact absorber (Figure 16). The purpose of the packed tower is to remove acid gases that exit the quench zone. Water is sprayed in the tower at the top and flows downward over plastic packing material, which maximizes its contact with the upward moving gases.

Upon leaving the packed tower, the gases flow into the ejector scrubber. The ejector scrubber, shown in Figure 17, serves two primary purposes: (1) to remove the fine particulate from the off-gases, and (2) to provide the motive force to draw the gases through the entire incinerator system. The ejector scrubber operates by injecting high pressure steam into the annular region of the ejector scrubber. The steam acts as the motive fluid in an ejector pump and also agglomerates the fine particles in the venturi section of the jet pump.

After leaving the ejector scrubber, the gases flow through a demister, also shown in Figure 17. The demister removes the condensate from the jet scrubber along with the agglomerated fine particulate captured in the condensate. The condensate water and particulate are pumped back to the ENT for recycling. The combustion gases and steam from the jet pump are then exhausted through the 40-foot tall stack, as shown in Figure 18 (see also Figure 3). The ejector scrubber, demister, and stack are mounted on a flatbed tractor trailer; however, the stack is installed at the field site.

C. PROCESS MONITORING AND CONTROL

The incineration process is remotely monitored and controlled from an operator's panel located in a mobile control room trailer. This panel contains numerical and status light indicators, switches, video monitors, and a computer monitor (many of which are shown in Figure 19) that provide the operator with process system parameters. Manual controls on the panel can be used to adjust system variables to required operating conditions.

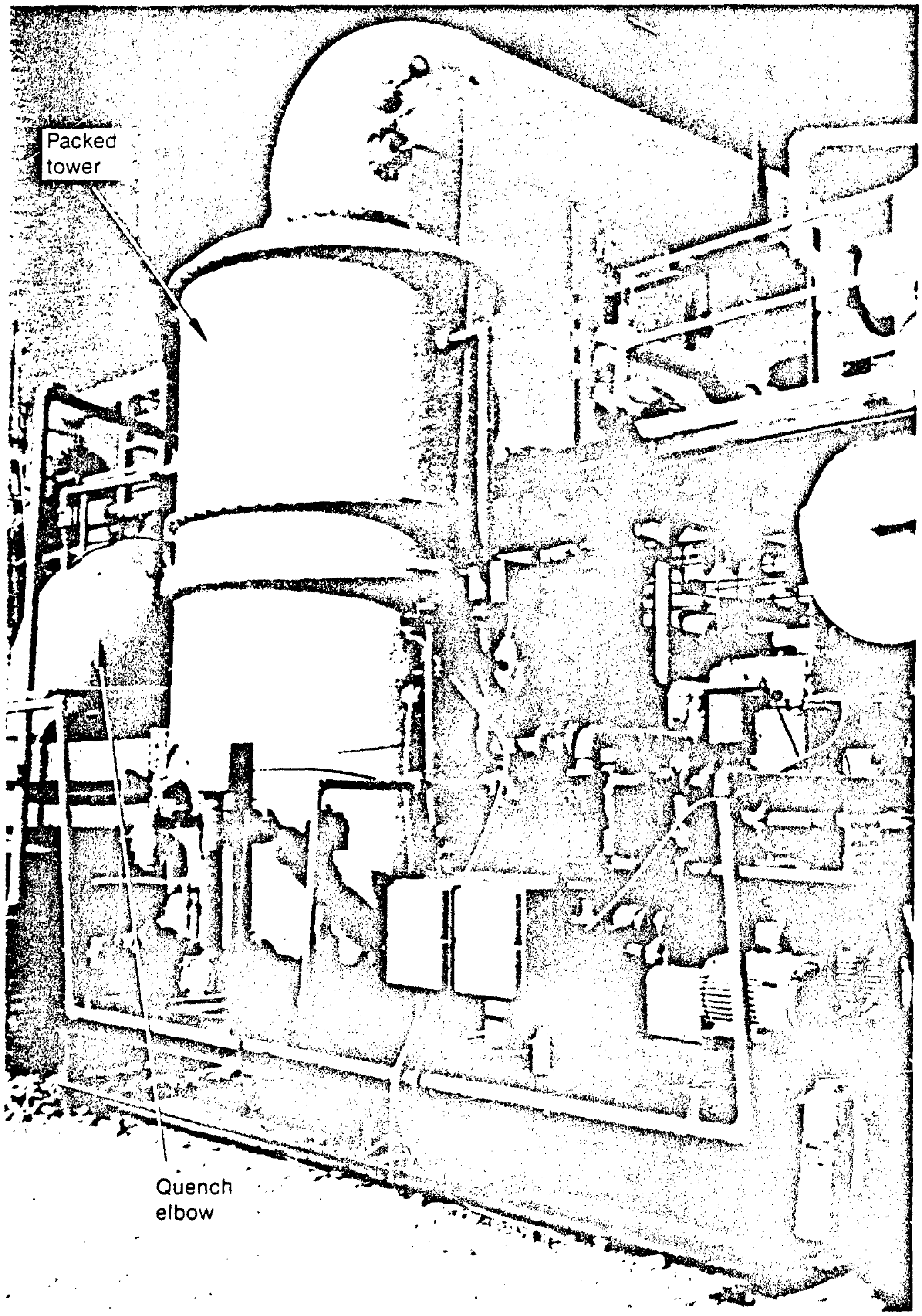

Figure 16. View of Skid-Mounted Packed Tower

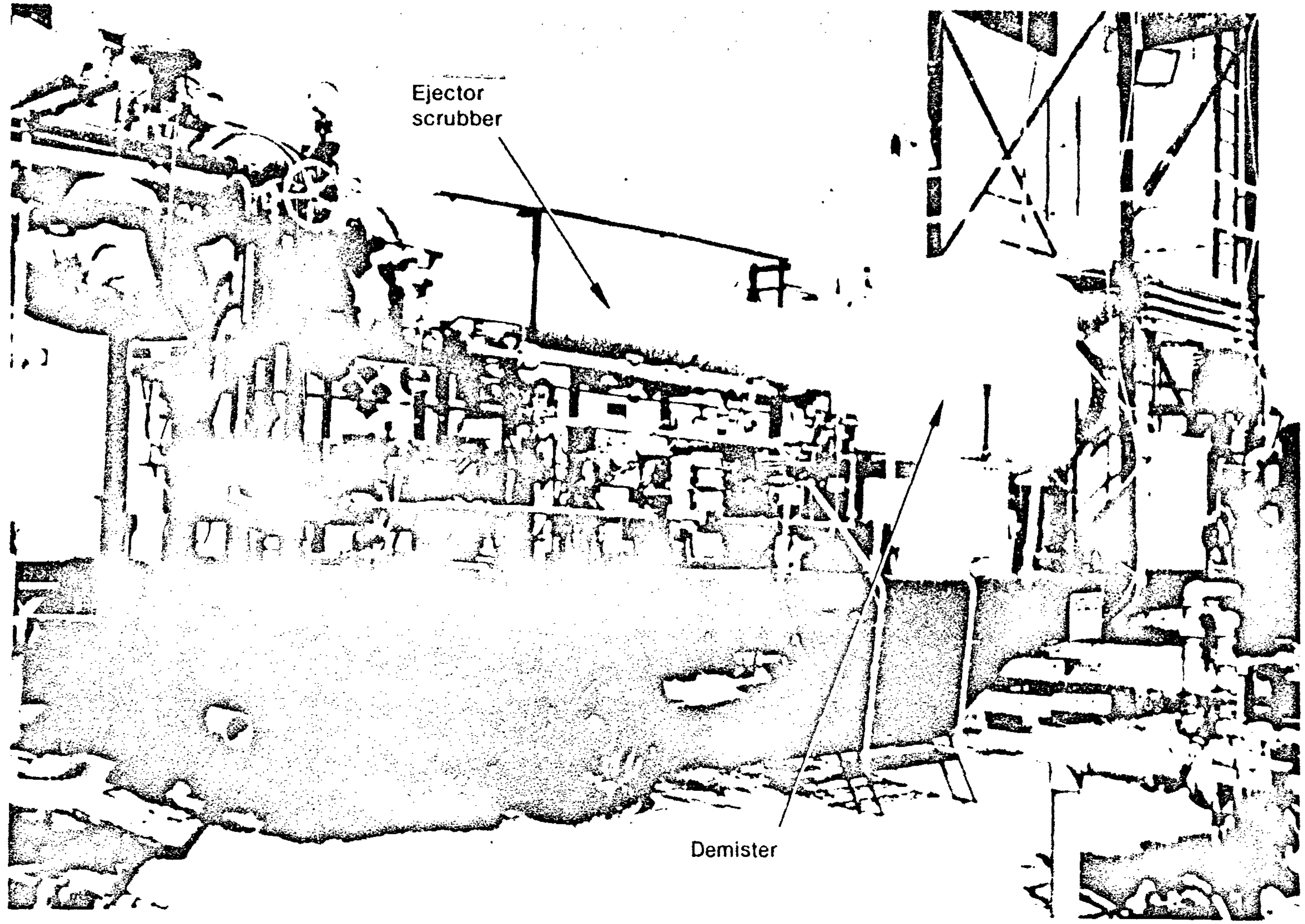

Figure 17. View of Trailer-Mounted Ejector Scrubber and Demister

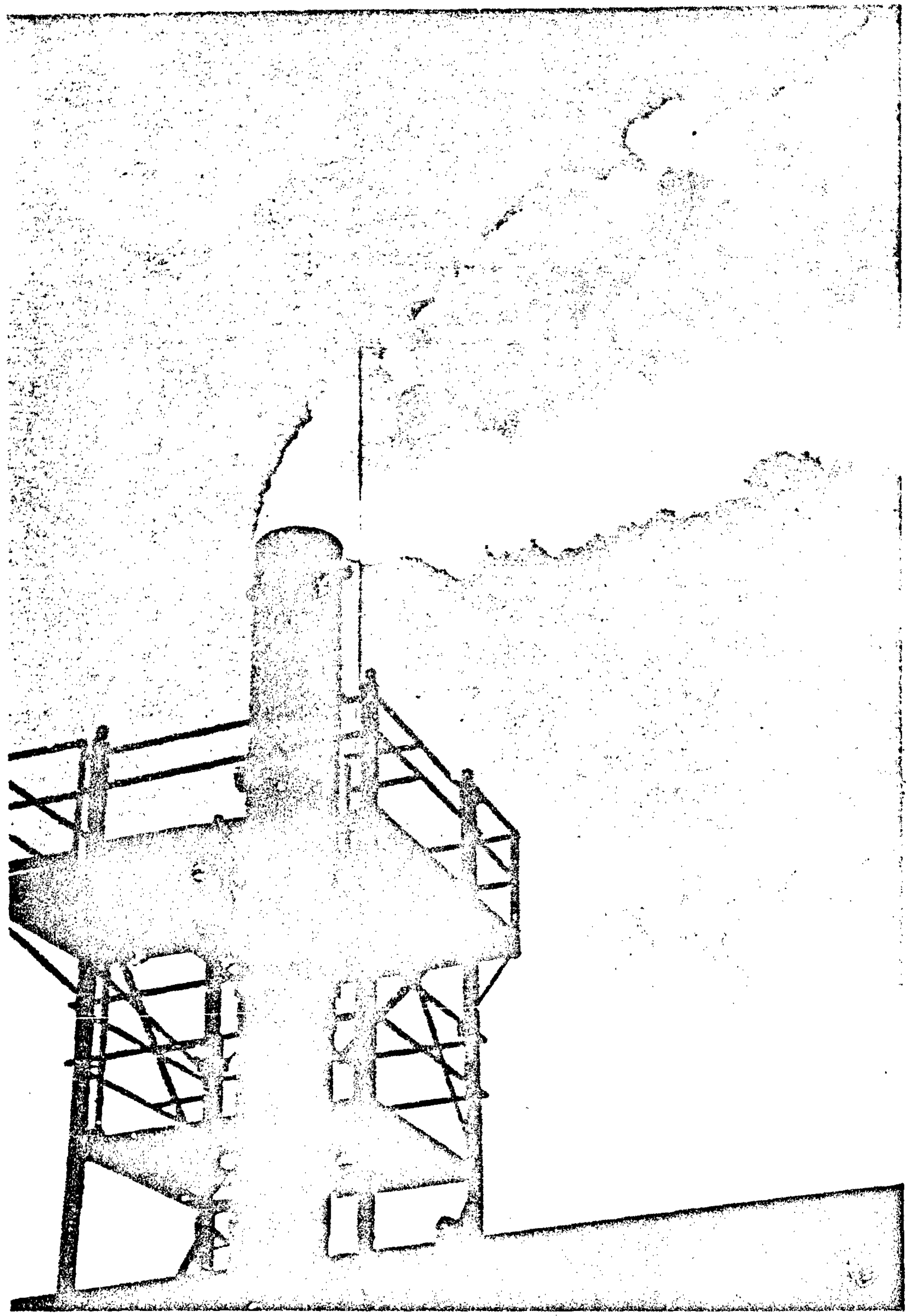

Figure 18. View of Incinerator Stack

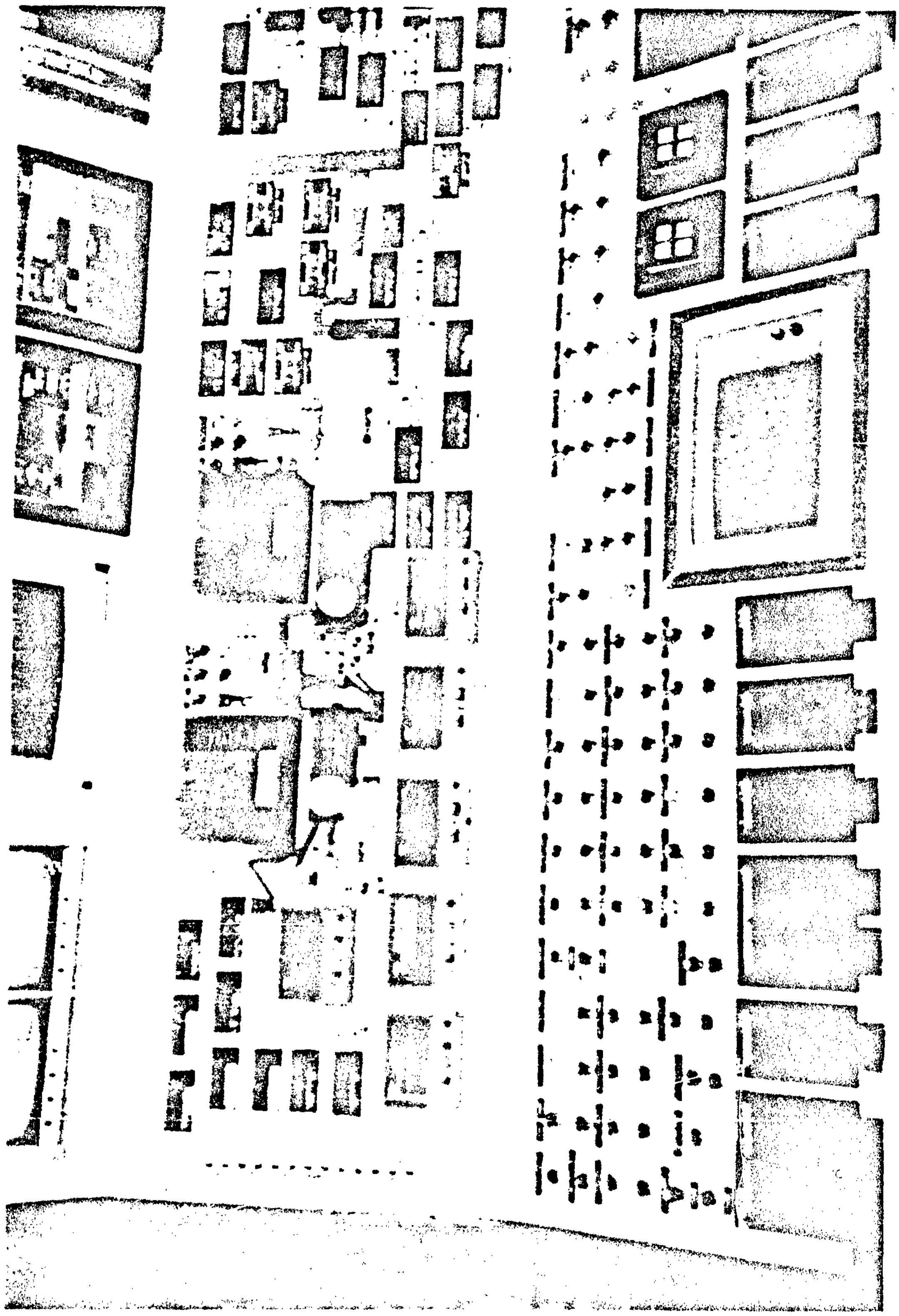

Figure 19. View of Incinerator Operator's Control Panel

Central to the control process is monitoring by a personal computer- based Data Acquisition System (DAS). The DAS collects data from electronic instruments that include a variety of thermocouples, pressure transducers, and level indicators. In addition, the stack gas emissions are continuously monitored for carbon monoxide, carbon dioxide, and excess oxygen content. The combustion efficiency being achieved by the MWP-2000 incinerator system is continually calculated by the DAS from readings from the carbon monoxide and carbon dioxide monitors.

When active, the DAS is also able to automatically stop waste feed if certain operational parameters fall outside of the EPA permit specifications or if the flame to the kiln or SCC fails. Details of the automatic waste feed shutoff (AWFSO) system are provided in Reference 2.

SECTION III
PROJECT PLANNING AND IMPLEMENTATION

This section was written to aid the potential project planner in developing a planning and implementation checklist for a remediation project similar to the NCBC Demonstration Project.

A. PROJECT MANAGEMENT PLAN

According to EG&G Idaho company directives, all projects must be planned and controlled in accordance with company policy. To implement this policy, a Project Management Plan (PMP) must be prepared before any work on the project can be initiated. The PMP must address the following 14 elements:

1. Work Scope
2. Work Breakdown Structure (WBS)
3. Organizations, Responsibilities, and Authority
4. Schedules
5. Budgets and Cost Estimate Basis
6. Resource Allocation Plan
7. Quality Program Plan (QPP)
8. Safety Plan
9. Security Plan
10. Management, Planning, and Control Plan
11. Reporting Requirements
12. Configuration Management Plan (CMP)
13. Change Control Plan
14. Appendix (reference data, procedures, etc.)

The information discussed in subsections III.B. through III.M. should be included in the PMP to the extent possible.

A summary of the NCBC Demonstration Project PMP can be found in Reference 3. The PMP included the statement of work scope between EG&G Idaho and the Air Force. The original work scope for the project entailed both pilot-scale and full-scale technology demonstrations. The objective was to determine the most cost-effective, currently available technology to return HO contaminated

sites to beneficial use. The technology demonstrations involved the following tasks:

1. Selection of technology subcontractor

2. Obtaining required permits and government approvals

3. Demonstrating the selected technology(s)

4. Preparation of technical reports.

B. ENVIRONMENTAL ASSESSMENT

Concurrent with the permitting process with EPA Region IV and the State of Mississippi, an environmental assessment (EA) of the proposed RD&D project activities was written and provided to base officials at the NCBC. The purpose of the EA was to assess the environmental impacts of site remediation. A copy of the draft EA is included in Reference 2.

The EA concluded that the proposed NCBC Demonstration Project would have no significant impact on the environment. By removing the dioxin contamination hazard from the former HO storage site, the proposed project would improve the environment by not only eliminating the human health hazard, but also by eliminating the possibility of spreading dioxin contamination to offsite areas.

The EA was submitted to the EPA as supporting documentation for the permit application. No comments were received from the EPA regarding the EA.

Because of the many personnel changes within the Air Force and EG&G Idaho on this project, the actual time to prepare the EA is not known. The theoretical time to prepare an EA is estimated at 6 months to 1 year, depending on the project, project location (state), and the availability of information.

C. PERMIT APPLICATION

1. Research Development and Demonstration Permit

The Hazardous and Solid Waste Amendment (HSWA) of 1984 gave EPA authority to issue RD&D permits, without promulgation of permitting regulations, which would establish standards for technologies or processes that treat hazardous waste in an innovative and experimental manner. In addition, permitting authority was given to regional EPA regional offices, as well as the authority to modify or waive the permitting and technical requirements applicable to other types of hazardous waste management facilities. The Air Force saw the need to develop soil decontamination technologies and therefore sought a RD&D permit frcm EPA Region IV.

2. Justification for an RD&D Permit

There are several Air Force sites that contain dioxin contaminated soil; one of them is the former HO site at NCBC. As the need for remedial action of those sites became apparent in the early 1980s, the Air Force also realized that there were few available technologies that were able to treat soil contaminated with TCDD. As a result, the Air Force, through its Installation Restoration Program, conducted three small-scale demonstration projects that demonstrated the feasibility of treating dioxin contaminated soil. Although those projects were successful, the technologies demonstrated were too small to conduct a full-scale site remediation. Therefore, the Air Force began to seek existing technologies that might be suitable for full-scale remediation.

A review of available information revealed that ENSCO's MWP-2000 mobile incinerator would be a likely candidate for full-scale remedial action. However, there were little data that would enable project planners to determine the cost and reliability of such a system. As a result, the Air Force decided to conduct a research demonstration project to determine the cost and practicality of using a mobile rotary kiln incinerator for processing soil contaminated with highly refractory organics, such as dioxin.

Because this was a research project, the Air Force, decided to pursue a RD&D permit from EPA Region IV. At the time of project initiation, the RD&D permit had certain logistical advantages over a Part B permit. In particular, the RD&D permits were intended to help develop safe alternatives for land disposal of hazardous waste by expediting the permitting process. Additionally, the HSWA of 1984 gave the regional authorities the authority to modify or waive the permitting and technical requirements applicable to other types of hazardous waste management facilities.

3. Early Permitting Activities

The Air Force submitted a RD&D permit application to EPA Region IV on January 20, 1986. Copies were also submitted to the Dioxin Disposal Advisory Group (a former group within EPA headquarters) an the Mississippi State Department of Natural Resources. Verbal comments were received and incorporated; and a revised application was submitted on May 9, 1986. Between these submittals, the ENSCO trial burn data and ENSCO's revised trial burn plan for polychlorinated byphenyls (PCBs) were made available to EPA Region IV.

After review of that information, EPA Region IV prepared a draft permit and provided it to the Air Force Engineering and Services Center (AFESC) and EG&G Idaho for review. Comments were submitted to Region IV on June 2, 1986. Because the project fell under RCRA, it was also necessary to submit a notification of hazardous waste activity to obtain a generator identification number.

Initial public notification of the intent to issue an RD&D permit for the full-scale testing was made by an AFESC representative in a briefing on March 18, 1986 to local city mayors from the region. On March 18 and 19, 1986 the AFESC and EG&G Idaho briefed all base personnel present at the NCBC, which numbered approximately 1,500. Also, an AFESC representative briefed the State of Mississippi Bureau of Pollution Control at Jackson, Mississippi. Additional details can be found in Reference 2.

The permit specified that the AFESC had to conduct a verification test burn using contaminated native NCBC soil. That test burn was conducted in

December, 1986. The data were submitted in January, 1987 at which time EPA Region IV informed the AFESC of the need to perform a RCRA trial burn (see Section III.J.1).

Because of extenuating circumstances, as detailed in References 2 and 4, final approval to commence routine soil processing was not granted until November 23, 1987. Total time from permit application submittal to final approval was 22 months.

As a result of changes in the EPA regulations, RD&D permits for demonstration projects which treat all the contaminated material at a site are no longer available.

4. Water Permit

Because of the planned connection to the NCBC sewer system, it was necessary to obtain a Publicly Owned Treatment Works (POTW) permit from the State of Mississippi Bureau of Pollution Control. An application was submitted on July 16, 1986. The Bureau of Pollution Control responded on September 9, 1986, with a draft final permit showing effluent limitations, schedule of compliance, monitoring requirements, and monitoring reporting dates. AFESC comments were sent to the Bureau of Pollution Control on September 19, 1986. A revised draft final permit was sent to the AFESC by the Bureau of Pollution Control on September 22, 1986. Also enclosed was a Public Notice dated September 30, 1986, which was declared the beginning of a 30-day comment period during which the general public's input and comments were invited. The POTW application was also coordinated by the Bureau of Pollution Control with the Harrison County Wastewater Management District, which expressed no objection to receiving the treated water. A 5-year pollution control permit was issued by the Mississippi Natural Resources Board for the project on October 31, 1986. The POTW permit can be found in Reference 4.

D. SAMPLING PLANS

1. Air

The Ambient Air Monitoring Plan for the NCBC Demonstration Project was prepared by EG&G Idaho (Reference 5). The plan provided the EPA, Region IV and project personnel at NCBC with the sampling and analysis protocols for monitoring the ambient air during routine excavation and incineration activities. The plan implemented the ambient air monitoring requirements specified in the RD&D permit. The plan was revised in February 1988 to reflect changes to the air monitoring requirements.

2. Operational Sampling Plan

The Operational Sampling Plan for the project encompassed the soil, ash, and water sampling procedures. The sampling process, handling, and quality assurance methodology can be found for each of the three subjects listed above in the sampling plan.

The sampling plan and its revisions were written by EG&G Idaho personnel. The complete plan can be found in Reference 6.

E. CONTRACT WITH INCINERATOR OWNER/OPERATOR

1. EG&G Idaho Contract with ENSCO

The subcontract for the NCBC Demonstration Project was considered to be a standard cost plus fixed fee (CPFF) subcontract. In a CPFF contract, the subcontractor submits a cost estimate prior to signing of the contract. Based upon this cost estimate, the contracting officer and the subcontractor negotiate a fixed fee or profit. If the actual costs for the project exceed the original estimate, the contracting officer will pay the excess legitimate costs, however, the fee remains fixed throughout the project for the given work scope. If the work scope expands by request of the contracting officer, an additional fee may be negotiated. This type of contract is generally used for research and development projects where there are numerous uncertainties in the scope of work.

To increase the tons of soil being processed per month, it was determined that an incentive fee over and above the 8% fixed fee would improve production. The incentive fee provided an additional profit to the subcontractor for processing soil at a rate above 2,000 tons per month. This revision to the ENSCO subcontract was implemented in March 1988.

2. Justification for Cost Plus Fixed Fee

a. Undefinable Work Scope

The NCBC Demonstration Project was the first of its kind, therefore the scope of work could not be defined sufficiently to negotiate a fixed price or unit price contract. Without a clearly defined work scope, a fixed price or unit price contract would have resulted in numerous change orders, probably costing more in the end than the cost plus fixed fee contract used.

b. Need for Reliability and Maintainability Data

A second reason for choosing a cost plus fixed fee contract was to obtain the incinerator reliability and maintainability information. With a fixed priced contract, the subcontractor would have no obligation or incentive to collect and provide detailed reliability, maintainability, and cost data for others to use.

3. Health and Safety and Permit Violation Clauses

To have some control over how the subcontractor achieved higher production rates, as discussed above in Section III.F.1 a $1,000 per incident penalty would have been deducted from the monthly incentive fee for any EPA permit violations. This penalty clause was negotiated as part of the contract revision that also added the production incentive fee. The incinerator subcontractor was not designated as a signatory on the permit, therefore, the Air Force would have been held liable for any permit violations. The penalty clause was added to provide a small incentive to adhere to the permit conditions. The EPA did not issue any citations for permit violations during the project.

Although no Health and Safety violation clauses were used in the contract for the NCBC Demonstration Project subcontractor(s), it may be worth considering for future projects. Occasionally, the project subcontractor personnel would perform tasks in an unsafe manner. When caught, they were given verbal reprimands, but without a contractual provision prohibiting such actions, nothing could be done to penalize the offenders.

4. Recommended Contract Strategy

For future projects similar to the NCBC Demonstration Project it may be advantageous to divide the project into several categories for contracting purposes.

a. Mobilization

The mobilization task should be performed under a fixed price contract. The mobilization task would include incinerator and related equipment transportation to the job site, site preparation (which includes utilities), incinerator setup, and initial hot testing.

b. Test Burn

The Test Burns to demonstrate 99.9999% DRE (or any other designator performance requirement) could be performed on a fixed price contract. The subcontractor performs the Test Burns until successful. The operations contract would not be awarded until the subcontractor successfully demonstrates required performance standard.

c. Hold Periods

Hold periods (time waiting permit or other approvals) should be fixed price per unit of time. As with the NCBC Demonstration Project, it would be based on a negotiated incinerator lease rate plus essential personnel. Since hold period time would be unknown at the time of contract negotiations, the hold period rate would be paid on a monthly basis.

Some scheduling could be used, but the time period may be indefinite. The subcontractor should not be penalized for holding time that is beyond his control. As an example, samples may be lost at the laboratory or the review time for permits or analytical data may take longer than originally anticipated.

d. Routine Operations

This part of the contract (or a separate contract) should be based on a price per ton or price per unit value. Included in operations would be soil excavation, soil storage, soil processing, utilities, office equipment, all personnel, and disposition of ash.

To avoid potential conflict of interest problems, sampling and analytical tasks should be performed by a different subcontractor.

e. Decontamination/Demobilization

As with the mobilization task, this task should be fixed price. Decontamination consists of swipe sampling all equipment used in the operations task, sample analysis, and cleaning equipment requiring decontamination. Decontamination standards and procedures should be established as much as possible prior to contract finalization.

Demobilization consists of dismantling the incinerator, loading the incinerator and equipment on trucks, returning the site to a predefined condition, and removing the incinerator and related equipment from the site.

f. RCRA Violations

To ensure that the subcontractor(s) are aware of the permitted operating parameters and their responsibilities, the subcontractor(s) must sign (or at least co-sign) the permit(s) and become fully responsible for any permit violations that they cause.

F. EQUIPMENT TRANSPORT

1. Road Permits

In planning the mobilization task, it may be necessary to obtain an overweight highway permit for large and heavy equipment such as the kiln and the SCC. Depending on individual state requirements, it may also be necessary to have state police escorts.

Because of the short length versus weight of the kiln (with refractory), most states will not allow the kiln to be transported via highway. Therefore, the kiln is shipped empty and the refractory is installed at the job site. Using barges or railroads may alleviate this problem.

2. Transportation

Transportation of the incinerator and related equipment to NCBC was accomplished using 13 tractor trailer trucks in convoy. As mentioned earlier, state police escort was required on Mississippi roads and interstate highways.

Upon completion of the NCBC Demonstration Project, it required 16 tractor trailer trucks to transport the incinerator and equipment from the site. The convoy required state police escort while travelling through Mississippi.

3. Demobilization

The same planning and permitting is required for demobilization as for mobilization. At the completion of the project, it was necessary to remove the refractory from the kiln at NCBC for transporting. The refractory was disposed at a hazardous landfill site in Louisiana.

G. EQUIPMENT SETUP

1. Site Preparation

The area selected for placement of the incinerator for the NCBC Demonstration Project was within the former HO storage site. The equipment layout is shown in Figure 20. The HO storage site was remote from other active facilities on the naval base. The specific area selected was based on the soil sampling program results, which showed dioxin contamination less than 1.0 ppb at that location; therefore, the location was declared clean.

Although the incinerator system was installed on a clean area, the weigh hopper/shredder system was not. Ten months into soil processing it was necessary to move the weigh hopper/shredder system to excavate the underlying contaminated plots. This task cost one week of downtime.

During equipment setup, the project planners realized that moving the weigh hopper/shredder would later be necessary. However, the planners also realized that the presence of the contaminated soil handling activities would likely contaminate any clean plot; therefore, the weigh hopper/shredder was placed on contaminated plots to avoid having to remediate those plots twice.

One potential method of solving this dilemma, would be to have a sealed soil feed system that would minimize the potential of contaminating clean plots upon which the equipment was located.

In addition to the incinerator and supporting equipment setup, it was necessary to setup a spare parts trailer, a personnel decontamination trailer, a sample trailer, and an office complex. The spare parts trailer was setup just inside the closure fence, but away from the contamination zones. The personnel decontamination trailer served as the entry point for all personnel entering the incinerator area from the office complex and so was situated on the fence line. The sample trailer was located outside the closure fence in the office complex area. This was done to minimize the possibility of cross contaminating the soil, ash, and water samples. The office complex consisted of a break trailer (a smoking and lunch area for operations and excavation personnel), an office trailer for ENSCO personnel (plant superintendent,

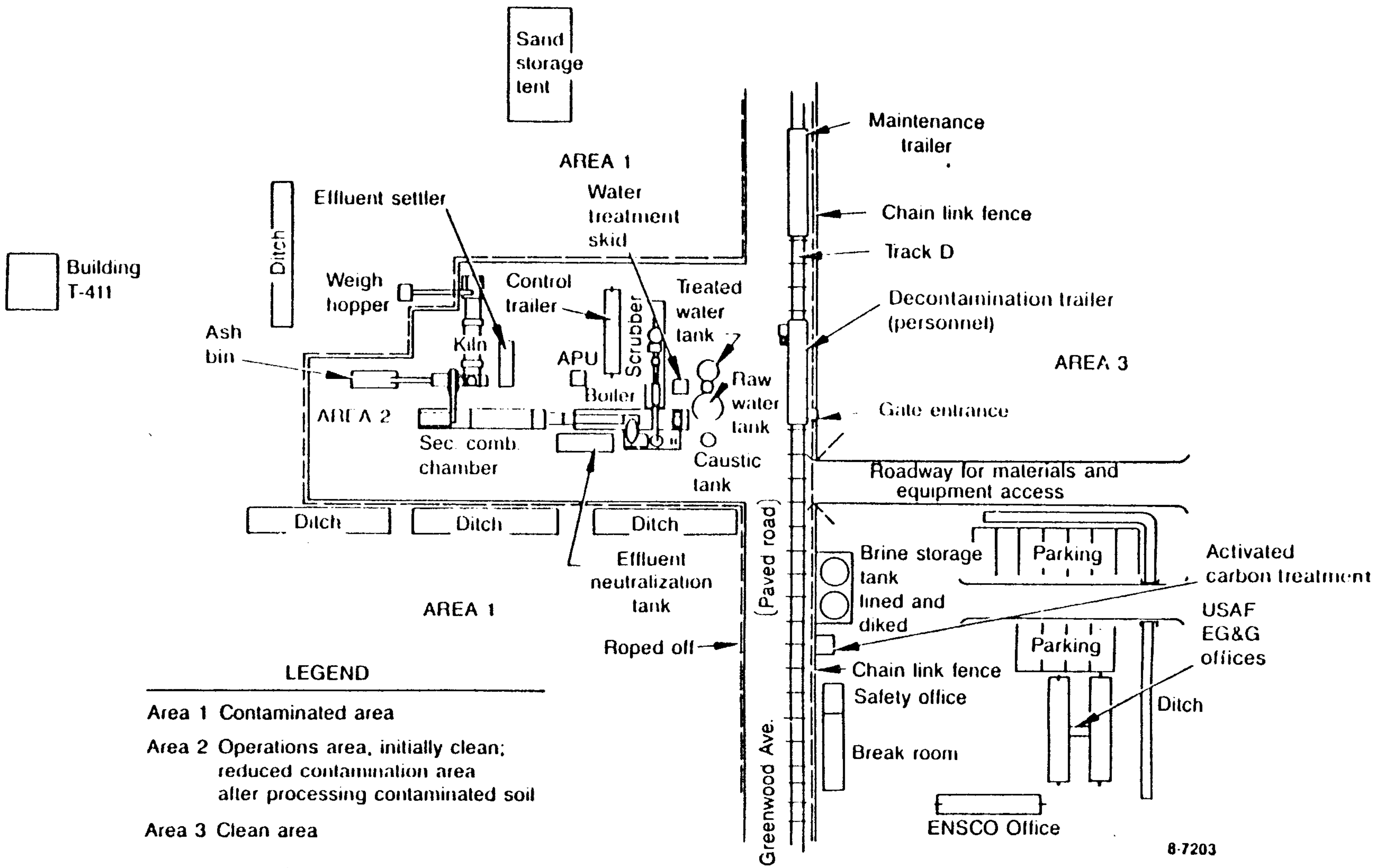

Figure 20. Site Layout for MWP-2000 Incinerator Setup at NCBC

bookkeeper, and purchasing agent), an office trailer for Versar, Inc. personnel and their weather station for air monitoring activities, a conference room trailer, and two trailers (side by side) for Air Force and EG&G Idaho personnel, the project secretary, and the data entry clerk.

2. Utilities

The utilities used at NCBC were natural gas, water, electricity, and telephone. The natural gas and water lines were installed by a local (Gulfport, Mississippi) firm. The power lines and telephone lines were installed by the local power and telephone companies.

A local subcontractor started the installation of the utility lines (gas, water, and sewage) on August 26, 1986 and completed the task on September 1, 1986.

Because the project was originally of short duration, the POTW (sewage) system was used for incinerator wastewater only and not wastewater from the office complex. Instead, the sewage system used for the office complex was a portable system that required pumping at least three times a week. For future projects it would be much more convenient to use the base or local sewage system and forego the problems of the portable system.

Although there were AT&T telephone lines installed at the office complex, most of these lines were connected to a feeder system called Eagle One®. The Eagle One® system handsets were operated off a power supply built into the Eagle One® control unit. Unfortunately, the power supply was not dependable. The power supply failed twice during the project, leaving the office complex with only the telephone from the telefax machine. After the second power supply failure, personnel were instructed to turn the unit off during thunderstorms, which are frequent on the Mississippi Gulf Coast.

Another problem was the reliability of the telephone system service company. The contract for servicing the Eagle One® system was transferred to several other companies as the companies were bought and sold to different parent companies; locating the correct service company proved difficult.

Upon analysis, the potable water at NCBC was found to contain silica levels unacceptably high for use in the waste heat boiler. The high silica would cause scaling on the outside of the boiler tubes. High blowdown rates to prevent scaling would result in loss of steam volume and subsequent loss of the injector scrubber. Scaling of the tubes would cause poor heat transfer and reduced steam production and ultimately loss of the jet scrubber. During the verification test burn, a tractor trailer sized deionizer unit was leased. The problem was ultimately resolved by the procurement of a desilicizer unit that was used to treat supplied water being fed to the waste heat boiler.

3. Training

All personnel engaged in field activities were required to undergo health and safety training and certification, and medical monitoring as stipulated by EPA order 1440.2.

The training for the NCBC Demonstration Project consisted of the following:

a. Orientation on the purpose of the project and how it was to be accomplished.

b. Information on the potential health hazards associated with the project, potential exposure routes, symptoms of exposure, and basic first aid treatment for exposure.

c. The care, donning, removal, and limitations of air purifying respirators and full-face, air-supplied respirators. Fit testing was provided for all employees and records maintained.

d. The care, donning, removal, and limitations of all other personnel protective equipment that personnel were required to wear.

e. The procedures for entering and exiting contamination areas and the importance of these procedures.

f. The signs, symptoms, and first aid treatment for heat stroke, heat cramps, and heat exhaustion, and the preventive measures for these ailments.

g. The reasons for prohibiting eating, drinking, and smoking in contaminated areas.

h. The locations and use of emergency showers and eyewashes.

i. The locations of fire extinguishers and first aid equipment and the proper use of this equipment.

j. The procedures to be followed when an alarm was sounded.

k. The location and use of communications equipment.

l. Roles and duties during an emergency.

m. The safe operation of the equipment that each person would operate.

Additionally, at least two persons on each shift were required to have valid American Red Cross or equivalent certificates in basic first aid and CPR.

All personnel who frequently worked in the contaminated areas were required to attend weekly health and safety meetings to reinforce the above training.

At the start of the annual hurricane season (June 1), all personnel working at NCBC were required to attend hurricane preparedness training. This training was presented by NCBC and local Emergency Action Coordinators.

4. Site Security

Because the work site was located on a military installation, it was not necessary to have dedicated security personnel. All personnel entering

the base were required to pass through a guard station manned by either Navy or contractor security personnel. Personnel entering the base had to show their personal picture identification badge, and if driving, the vehicle had to have the proper identification sticker.

To keep unauthorized Naval Personnel from entering the area from side roads paralleling the work site or via the railroad tracks, NCBC security placed barricades at these locations.

Base security personnel made frequent routine security checks of the work site fence line and office area. To gain access to the incinerator area, personnel had to pass through the personnel decontamination trailer. With the project operating on a 24 hours a day, seven days a week schedule, it would have been very difficult for unauthorized personnel to enter unnoticed.

5. Duration

The preparation of the site for the incinerator system began on September 8, 1986. The equipment and supporting equipment arrived on September 17, 1986. System setup began on September 29 and was completed on October 19. The system setup was performed by the ENSCO personnel that built the unit in White Bluff, Tennessee and consisted of 17 people, mainly laborers. At the completion of the setup, most of the personnel were sent back to White Bluff. Only those personnel essential to perform the system checkout such as Electrical and Instrumentation Technicians and Operators remained at NCBC. Systems checkout began on October 20 and was completed on November 14. The operational testing of the incinerator was completed on November 24.

6. Problems Encountered During Setup

a. Inclement Weather

During equipment setup, foul weather plagued the Mississippi Gulf Coast region. There were numerous thunderstorms and long drenching rains. Some storms lasted for several days and dropped several inches of rain each

day. As a result, the construction crew was unable to safely work during the storms and equipment setup was delayed.

Between mid-September, when equipment setup began, and late December, when the verification test was completed, approximately three weeks were lost due to foul weather.

b. Utilities

The natural gas line was installed prior to installation of the incinerator. As a result, the end of the gas line was improperly located with respect to the needs of the incinerator. Detailed planning could have eliminated the need to relocate a section of the natural gas line.

c. Financial Accounting

Another basic procedural problem that was endemic to the incinerator subcontractor was the lack of adequate financial accounting. The incinerator subcontractor did not have adequate procedures in place to accurately track the costs of material, travel, and labor expenses in a timely manner. As a result, project personnel had great difficultly in determining the actual project costs. This problem was ultimately fixed, but the procedures should have been in place prior to the commencement of work onsite.

7. Costs

The costs for the incinerator and supporting equipment setup was $342,863. In addition to the setup costs, the project incurred costs of $130,719 for site preparation. These costs include site services (telephone, secretarial, accounting, office rental, office equipment rental, etc.) which amounted to $4,280 per week.

H. VERIFICATION TEST BURN TEST PLAN

The goals of the verification test burns included the following:

1. To determine if the MWP-2000 could reduce the concentrations of tetra-, penta-, and hexachlorodibenzo-p-dioxins and the tetra-, penta-, and hexachlorodibenzofurans to levels less than 1.0 ppb.

2. To verify whether the incinerator is capable of processing the cement-stabilized soil without producing additional listed or characteristic hazardous waste.

3. To ensure that the operation of the incinerator does not cause any adverse effects to human health or the environment.

Significant planning activities were completed to ensure safe and timely accomplishment of the project goals. Those planning activities included the following:

1. A test plan for verification test burns.

2. A health and safety plan.

3. An emergency and contingency plan.

4. A spill prevention control and countermeasures plan.

5. A sampling plan.

ENSCO prepared the health and safety plan and submitted it to EG&G Idaho for review. Versar prepared the sampling plan, which included the supporting quality assurance/quality control (QA/QC) plan, and submitted it to EG&G Idaho for review. EG&G Idaho prepared the test plan and spill prevention control and countermeasures plan and jointly prepared the emergency and contingency plan with ENSCO. All documents were submitted to the AFESC Project Representative for review before the verification test burns. Each of these

plans is briefly described below. Additional details can be found in Reference 2.

1. General Plan

The general plan for the MWP-2000 verification test burns included: (1) incinerator setup and checkout, (2) soil preparation and handling, and (3) incinerator operation. Approximately 270 tons of clean and contaminated soil were planned to be processed during the verification test burns. EG&G Idaho/AFESC project management designated the soil excavation locations for contaminated soil based on results of surface soil sampling. Soil with the highest known contamination levels was used to best demonstrate the capabilities of the treatment technology.

2. Incineration Test Plan

The test plan called for at least three different feed rates ranging from 3 tons/h to 5 tons/h. Additionally, all thermal and mechanical operating parameters, such as kiln temperature and kiln rotational speed, were specified in the test plan. The test was not allowed to proceed until all parameters were within their specified operating limits.

The planned approach was to reach operating conditions and operate with clean soil (approximately 240 tons) for 3 days of continuous operation and then follow with individual contaminated soil test runs. Periods of standby operation (no soil being fed) were phased between the initial clean soil checkout and the different tests in order to provide distinct identification for process sampling.

The planned incinerator operating conditions are listed in Table I for both the Verification Burn and the RCRA Trial Burn, described in Section III.J.

TABLE 1. PLANNED OPERATING CONDITIONS AND MONITORED PARAMETERS FOR VERIFICATION TEST BURNS

Parameter	Normal Range or Setpoint	
	Verification Burn	Trial Burn
Nominal soil feed rate	Variable 3-5 tons/h	Test 7: 4 tons/h Test 8: 5 tons/h[a,b]
Soil residence time	Variable 20-60 min	Variable 20-60 min
Kiln combustion air flow rate	120 lbs/min	120 lbs/min
Kiln outlet gas temperature[c]	1600-1800°F	1350-1800°F
Kiln pressure[c]	negative pressure	negative pressure
Secondary combustor combustion air flow rate	300 lbs/min	300 lbs/min
Secondary combustor outlet gas temperature[c]	2150°F minimum	2100°F minimum
Secondary combustor pressure	negative	negative
Outlet soil temperature	1600-1800°F	not specified
Gas residence time in secondary combustor[a]	1-2 s	1-2 s

TABLE 1. PLANNED OPERATING CONDITIONS AND MONITORED PARAMETERS FOR VERIFICATION TEST BURNS (CONTINUED)

Parameter	Normal Range or Setpoint	
	Verification Burn	Trial Burn
Combustion efficiency[a]	99.0%	>99.0%
Boiler outlet gas temperature	450°F	450°F
Boiler steam pressure	220-240 psig	220-240 psig
Steam drum level	40-60%	not specified
Boiler makeup water flow rate	20-30 gpm	20-30 gpm
Quencher recirculation water flow rate	100 gpm	100 gpm
Quencher makeup water flow rate	15 gpm	15 gpm
Quencher outlet gas temperature	190°F	190°F
Packed tower recirculation water flow[c]	170 gpm	170 gpm[c]
Packed tower makeup water flow rate	15 gpm	15 gpm

TABLE 1. PLANNED OPERATING CONDITIONS AND MONITORED PARAMETERS FOR VERIFICATION TEST BURNS (CONTINUED)

Parameter	Normal Range or Setpoint: Verification Burn	Normal Range or Setpoint: Trial Burn
Scrubber recirculation water flow rate[c]	40 gpm	40 gpm[c]
Stack gas oxygen[c]	3% minimum	3% minimum
Stack gas CO[c]	50 ppm	50 ppm
Stack gas CO_2	Function of combustion efficiency	Function of combustion efficiency
HCl emissions	1.8 kg/h or 1% of HCl concentration into the scrubber, whichever is greater	1.8 kg/h or 1% of HCl concentration into the scrubber, whichever is greater
Particulate matter	180 mg/dscm corrected for O_2	180 mg/dscm corrected for O_2
Scrubber effluent water		
2,3,7,8-TCDD	Not detectable	Not applicable
2,4,5-T	Not detectable	Not applicable
2,4-D	Not detectable	Not applicable
pH	5.5-9.5	5.5-9.5

TABLE 1. PLANNED OPERATING CONDITIONS AND MONITORED PARAMETERS FOR VERIFICATION TEST BURNS (CONCLUDED)

a. The trial burns conducted in May 1987 were to be designated as Tests 7 and 8 so as to not be confused with the verification test burns conducted in December 1986, designated as Tests 1-6.

b. Test 8 was later cancelled because the average feed rate of the three replicates for Test 7 exceeded 5 ton/hour

c. Indicates parameter is a specified permit condition.

3. Sampling Plan

a. Sampling

Versar, Inc. of Springfield, Virginia, wrote a detailed sample collection plan and its associated quality assurance plan. During testing, Versar obtained all onsite test samples and sent them to IT Analytical Services (ITAS) in Knoxville, Tennessee, for analysis. The detailed test plan is provided in Reference 2.

ITAS is a certified participant in the EPA Contract Laboratory Program (CLP). EG&G Idaho Chemical Sciences performed a review of the ITAS QA/QC program prior to the laboratory analysis and later reviewed the submitted data.

To evaluate the effectiveness of ENSCO's incinerator for treating soil containing 2,3,7,8-TCDD and other chlorinated organics, Versar thoroughly reviewed the incinerator process and examined all potential release points and points of potential cross-contamination. Based upon that review, samples were collected from the points listed in Table 2.

Some of the aforementioned samples were not directly needed to determine compliance with project goals. Those samples, called secondary samples, were collected and stored onsite; analysis was planned for secondary samples only if cross-contamination was detected or if the primary samples were lost or damaged. Because the primary samples successfully satisfied the project goals, the archived samples were not analyzed. Additional details concerning sampling for the verification test burns can be found in Reference 2.

Stack gas samples were obtained in the stack via two 4-inch flanges, located 90 degrees apart approximately 6 feet below the top of the stack. The specific methods used were an EPA Modified Method 5 gas sampling train and a Volatile Organic Sampling Train (VOST). Both trains were used simultaneously. Two different sampling metnods were needed because of the widely varying physical characteristics of the trace organic compounds that potentially could have been emitted from the stack.

TABLE 2. LOCATION OF VERIFICATION TEST BURN SAMPLES

Location	Primary or Secondary
Feedstock soil (untreated soil)	Primary
Treated soil	
- directly from the kiln	Secondary
- directly from the ash drag	Primary
Stack gas	Primary
Effluent neutralization tank	Primary
Quench/scrubber fines	Secondary
Boiler water blowdown	Primary
Water discharge to POTW	Primary
Blanks (tap water)	Primary

To meet the goals for the verification test burns with respect to delisting (described in Section III.J.), the laboratory analysis was tailored to the specific project needs. The final constituent list is specific to the NCBC site and includes 130 constituents. The complete list can be found in Reference 2.

b. Sample Shipment

All samples collected during the verification test burns were packaged and shipped to the analytical laboratory in accordance with U.S. Department of Transportation regulations. To meet time constraints, all samples were shipped by Federal Express.

4. Health and Safety Plan

ENSCO prepared a Health and Safety Plan for the NCBC incinerator testing. This plan was derived from standard health and safety procedures developed and used routinely by ENSCO personnel during operation of earlier units. It included unique aspects of the MWP-2000 and NCBC site. The plan was approved by certified industrial hygienists at both ENSCO and EG&G Idaho and met EPA Region IV approval through the permit process. Additional details can be found in Reference 2.

5. Spill Prevention Control and Countermeasures Plan

The spill prevention control plan described the methods and equipment that were intended for use in the event of any spill that potentially contained hazardous substances. As part of the planning task, a thorough inspection of the site was performed in an effort to locate and quantify sources of potential hazardous substance spills. The largest quantity of potentially hazardous substance was determined to be the effluent neutralization tank and the POTW storage tank. Both tanks were located within bermed areas to contain any potential spills. Additionally, stockpiles of absorbent clay and sand were available as additional berm material, if necessary.

6. Emergency and Contingency Plan

An emergency and contingency plan was developed to provide generalized guidance for contingency events associated with certain emergency activities at the NCBC, such as general evacuation due to hurricane and fire. Additionally, the plan provided specific direction for personnel action in the event of incinerator malfunction, or personnel injury, or fire. The plan also required the use of personnel protection equipment as specified in the Health and Safety Plan.

7. Field Organization

ENSCO performed the incinerator operation and soil excavation activities. Those activities were supervised by an ENSCO plant superintendent

located onsite. During the verification test burns, the MWP-2000 operations personnel were organized into two shift crews of about 10 persons each for two shift operations. A skeleton crew was used for the remaining nonoperating idle condition shift.

Versar performed the onsite sampling with a crew of about 10 personnel. These activities were coordinated with ENSCO onsite supervision.

EG&G Idaho and AFESC project personnel provided the technical monitoring in the field. During field tests, this monitoring served to observe, direct (but not supervise) subcontractor personnel, and to ensure procedural compliance by the demonstration and sampling effort. AFESC project representatives were also onsite during the demonstration to provide liaison between the Air Force and the Navy, as necessary.

8. Data Results Reporting

The operational data that were recorded onto floppy disks were converted into Lotus® spreadsheets and analyzed immediately following each test to determine if the test met the conditions specified in the test plan. Only one test was determined to be an operational failure; the mass feed rate was highly erratic.

Similarly, the physical stack gas sampling data were analyzed following each test. All stack sampling campaigns were successful.

EG&G Idaho received the analytical data approximately 30 days following the last test. The data were analyzed by EG&G Idaho Chemical Sciences, project personnel, and the Air Force representative to determine if the verification test objectives were met.

The data from the analytical laboratory were collated into a brief report and submitted to EPA Region IV for approval to commence routine operations. EPA Region IV reviewed the report and EG&G Idaho incorporated their comments and resubmitted the data package on February 17, 1987.

As discussed in Section III.H., EPA denied permission to commence operations due to the failure of a similar MWP-2000 to achieve the required Destruction and Removal Efficiency (DRE). Since the verification test was not designed to demonstrate performance to this criteria, a trial burn (described in Section III.J.) was designed and scheduled.

I. PROBLEMS ENCOUNTERED DURING VERIFICATION TEST

1. Inclement Weather

As during equipment setup, inclement weather continued to disrupt incinerator testing. During testing, safety precautions precluded anyone from working on the metal scaffolding during a thunderstorm. Approximately one week was lost during the December testing period due to inclement weather.

The inclement weather during the verification test burn also caused the soil that was to be processed to contain an exceedingly high amount of moisture. The high moisture content made processing very difficult because the soil would bridge over the feed auger. Additionally, the incinerator's processing capability was stretched to its limit; the incinerator had to dry out the soil before the organic desorption could be accomplished. The additional volume of gas produced by the drying was unable to be handled by the jet scrubber.

To extend the capacity of the jet scrubber, the nozzle in the scrubber was removed and machined to a larger diameter. The modified nozzle easily handled the additional moisture content even at the high soil feed rates.

2. Procedures and Approvals

During setup and testing, numerous problems were encountered because of the lack of well defined procedures and the project and operation personnel's understanding of the existing procedures. One such example occurred early in thermal testing when a positive pressure event occurred in the kiln. This caused hot combustion gases to reverse flow momentarily and flash back into the feed auger area and then ignite the feed conveyor. Operations personnel extinguished the fire and spliced the conveyor feed belt

the following day; no injuries were reported but one day of operational testing was lost. The event could have been prevented by leaving a plug of soil in the feed auger at all times. At the time of the event, the existing operation procedures did not include such provisions. A modification to the procedure and operator training prevented the recurrence of this event.

During the verification test burn, Test 4 was scrubbed because of widely varying soil feed rates. The feed rate varied from 1.9 tons/h to 5.2 tons/h. A post test debriefing of operations personnel revealed that they were unaware of the mass feed rate requirements for the test; they had been focusing their attention on the incinerator thermal conditions instead. Although the test plan clearly stated the test operational goals, project management personnel did not communicate the requirements to operations personnel adequately. As a result, a half day of testing was lost.

Approximately one week prior to the verification test burns, project personnel conducted several readiness review meetings. The purpose of the meetings was to determine if all equipment, personnel training, and procedures were in place so that the tests could be successful. The readiness reviews revealed a variety of items that were corrected prior to the test that could have jeopardized the successful test completion. One such example was the lack of instrument checkout and equipment lineup procedures. The incinerator subcontractor had no list of critical instrumentation or any documentation to assure project personnel that the critical instruments were on-line, calibrated, and functioning properly. Similarly, there was no documentation to show that critical equipment was functioning properly. Because of the simplicity of the MWP-2000, the necessary documentation was quickly developed and implemented; as a result several small instrumentation and equipment problems were revealed and corrected prior to the test.

J. RCRA TRIAL BURN TEST PLANNING

1. Test Justification

EPA requires that incinerators burning hazardous waste must meet three performance standards. As specified in 40 CFR 264.343, these standards are listed below:

- The concentration of particulate in the system's stack gas must be below 180 mg per dry standard cubic meter (This concentration must be corrected to 7% O_2, for reporting consistency.)

- The total stack emission of chloride (expressed as HCl) must be less than 1.8 kg per hour.

- The Destruction and Removal Efficiency (DRE) for each Principal Organic Hazardous Constituent (POHC) must meet or exceed 99.99%, or 99.9999% if the waste processed is an F027 listed waste as in the case at NCBC.

The DRE calculations are based on the mass feed rate of a contaminant compound into the incinerator and the mass emission rate of that compound from the stack. Specifically, the expression is

$$\text{DRE (percent)} = \frac{(W_{in} - W_{out})}{W_{in}} \times 100 \qquad (1)$$

where

W_{in} = mass feed rate one POHC in the waste stream feeding the incinerator.

W_{out} = mass emission rate of the same POHC present in the exhaust emissions prior to release to the atmosphere.

These performance criteria were part of the RD&D permit for the MWP-2000 incinerator operation at NCBC. EPA Region IV had previously agreed that a RCRA trial burn to demonstrate 99.9999% ("six 9s") DRE would not be necessary for the MWP-2000 unit located at NCBC. That agreement was made on the premise that an identical ENSCO owned MWP-2000 incinerator located in El Dorado, Arkansas, had already demonstrated compliance with the 99.9999% DRE requirement. The verification test burns at NCBC in December 1986 were only intended to demonstrate to the EPA that the MWP-2000 could process native NCBC soil without producing hazardous effluents.

The MWP-2000 incinerator located in El Dorado, Arkansas, underwent a RCRA trial burn in the spring of 1986. In late autumn, before the December 1986 verification test burn at NCBC, EPA Region VII notified ENSCO that the RCRA trial burn at El Dorado failed to demonstrate the required 99.9999% DRE. ENSCO did not notify the Air Force, EG&G Idaho, or EPA Region IV of this shortcoming. As a result, the verification tests proceeded as planned and achieved the Air Force goal to demonstrate that no hazardous effluents would be released when processing native NCBC soil.

During the verification test burns, two of the three criteria were demonstrated: (1) the limits on HCl and, (2) particulate matter emissions from the stack. The DRE of 2,3,7,8-TCDD could not be demonstrated by the process because the dioxin concentration in the HO-contaminated soil was not sufficiently high to be able to calculate a DRE meeting the EPA limit of six 9s in 40 CFR 264.343(a). No 2,3,7,8-TCDD was detected in the stack gas samples, and high resolution mass spectrometry (HRMS) was used to achieve lowest possible detection levels; four 9s were demonstrated ranging from 99.9968 to 99.9985%. Two test burns met six 9s for the herbicide 2,4,5-T; however, EPA recommends that three test burns should meet this POHC performance requirement. Additional information concerning the verification test burn results can be found in Section IV and in Reference 7.

It is important to note that the five verification test burns achieved the original AFESC goal that the treated soil PCDD/PCDF congener sum (tetra, penta, and hexa) be less than 1.0 ppb. Additionally, the data results indicated that delisting was plausible.

After careful examination of all available data and extensive discussions with EPA Region IV, it was determined that the herbicide results were not sufficient to satisfy the POHC performance requirement; a trial burn of the MWP-2000 incinerator system would be required to demonstrate this capability before full-scale soil restoration could proceed at the NCBC.

Following the decision to perform a RCRA trial burn, project personnel from all contractors were mobilized to write a trial burn plan. The draft plan was submitted on March 17, 1987, approximately one week following the decision to perform the test. EPA comments were received on March 27, 1987. The plan was

revised and resubmitted on April 17, 1987. The tests were scheduled for a 25-day period on May 1, 1987. This accelerated schedule caused numerous logistical and technical problems. The remainder of this section describes the planning efforts that were needed to perform the trial burn.

2. Surrogate Soil and POHC Selection

Because the concentrations of contaminating constituents were not sufficiently high enough to achieve the desired analytical sensitivity, a surrogate POHC feed was necessary. Two POHCs were selected as surrogates for the HO-contaminated soil: hexachloroethane (HCE) and 1,2,4-trichlorobenzene (TCB). The selection rationale for each is summarized below. A detailed discussion of surrogate soil and POHC selection is presented in Reference 7.

Hexachloroethane was selected as a POHC primarily as a result of its low heat of combustion value (0.47 kcal/gram). Of the hazardous constituents listed in Appendix VIII of 40 CFR 261, HCE is ranked third on the EPA's list ranking the incinerability of organic hazardous constituents on the basis of heat of combustion. HCE is the highest ranked solid compound by this same system. HCE is a solid below 367°F and has a low vapor pressure that reduces fugitive emissions and provides maximum flexibility during waste preparation.

1,2,4-trichlorobenzene was selected as the second POHC because this compound has a heat of combustion value (3.4 kcal/gram) that is very close to TCDD (3.43 kcal/gram) and has favorable physical and chemical properties. The relatively low toxicity and low vapor pressure were also considerations in the 1,2,4-TCB selection.

Another advantage of using these two compounds is that both HCE and 1,2,4-TCB can be detected by using the same analytical procedure as EPA Method 8270.

EPA Region IV denied permission to use native NCBC soil for the trial burns; that denial ultimately became technically and logistically advantageous. The native NCBC soil is a sandy matrix that was mixed with portland cement as a stabilizer. When the soil is excavated, the large chunks of cement must be crushed or shredded. At the time of the trial burn, large

rock crushing equipment was not readily available and the existing shredder located below the weigh hopper had not been reliably demonstrated.

Additionally, the potential presence of other organics from road tar in the native soil had not been confirmed or denied. It was felt that those potentially existing organics could contribute to analytical interferences in the POHC analysis.

Therefore, project personnel decided to use a surrogate soil matrix in order to avoid potential mechanical and analytical problems associated with native soil. Previous trial burns performed by ENSCO on another MWP-2000 incinerator had used clean builders sand as a surrogate soil matrix. Those tests indicated that no significant solid feed problems were encountered; therefore that experience was employed for the NCBC trial burn.

3. Surrogate Mixing

The original trial burn plan called for blending of the surrogate POHC with the sand by using a cement mixer. To meet desired concentrations, at least 200 pounds of each surrogate was estimated for each 9 cubic yard batch, and the surrogate would be added in four discrete equal positions and thoroughly mixed. The POHC and sand mixture was mixed in a cement mixer with samples taken at hourly intervals. Analysis of the mixture showed that the POHC concentration was approximately one fourth of the calculated concentration. This was true regardless of the mixing time.

An alternate method was tried in which the POHC was mixed with cotton seed hulls, which were in turn mixed with the sand in the cement mixer. It was quickly apparent that this method would also fail because the cotton seed hulls were visually observed to float to the top of the sand.

After these methods proved futile, EPA Region IV suggested that the POHC be placed in combustible containers that could be dropped into the waste feed at discrete intervals. This method was previously suggested by the Air Force contractors but rejected by EPA. The alternate POHC injection method was formally submitted to and accepted by EPA Region IV.

In the alternate method discrete quantities (1.5 pounds nominal) of the pure POHC were placed in polyethylene containers. The containers were then placed in the kiln feed hopper every 3 minutes during the test. This alternative method of feeding the surrogate compounds to the process provided a higher degree of assurance that the POHC would enter the incinerator, while reducing the chance of inhalation or cross-contamination in the vicinity of the feed hopper. To ensure system equilibration with POHC, the POHC was introduced into the kiln at least 45 minutes before the stack test began.

Because the incinerator system had been previously exposed to HO contaminants during the earlier verification test burns, the possible effects of cross-contamination were a concern. Planning called for the ENT, scrubber sump, packed tower, and ash drag sump to be thoroughly rinsed before incinerator warmup. This rinse water was discharged to the POTW effluent storage tank via carbon bed filters. Samples were taken to ensure concentrations of 2,3,7,8-TCDD, 2,4-D, and 2,4,5-T were nondetectable before discharge of the water in the sewer line.

4. Planned Operating Conditions

The overall plan for the MWP-2000 incinerator system trial burn was to start up the incinerator, run a clean soil test, blend the surrogate in clean sand feedstock, conduct two tests with three replicates each and then shut down the incinerator. The regulations for trial burn testing require continuous monitoring of contaminant mass flow rate and combustion temperature as well as carbon monoxide (CO), carbon dioxide (CO_2), and oxygen (O_2). The first test was planned for a nominal feed rate of 4 tons/h and the second test was planned for a nominal feed rate of 5 tons/h. The planned thermal and mechanical operating conditions are presented in Table 1 (Section III.H.2). Both the kiln and SCC were fired on natural gas.

5. Planned Sampling Methods

Versar, Inc. of Springfield, Virginia, wrote a detailed sample collection plan and its associated quality assurance plan. During testing, Versar obtained all onsite test samples and sent them to IT Analytical Services (ITAS) in Knoxville, Tennessee, for analysis.

To evaluate the effectiveness of ENSCO's incinerator for treating the sand spiked with 1,2,4-TCB and HCE, Versar collected the following samples according to the sampling plan:

1. Feedstock sand

2. Treated solid residue (ash drag)

3. Stack gas

4. Effluent neutralization tank

5. Background (clean sand, clean feedstock and its processed ash drag residue and ENT water, tap water, and stack gas sampling premixed reagents).

These sample points are identified in the incinerator process shown in Figure 21. Specific sampling procedures are described in Reference 7.

Due to the change in POHC addition methods, Versar also collected samples of the neat POHC. The background samples for the clean feedstock, processed ash drag residue, and ENT water were to show the system was not contaminated before starting the trial burn tests.

The draft trial burn plan called for sampling of the feedstock sand/POHC mixture at 15 minute intervals. As discussed in Section III.J.3, the POHC feed to the incinerator was modified to allow direct feeding rather than first mixing it with the sand. Therefore, the sand was not sampled during the trial burn tests, however, background samples were taken.

The residence time of the solids in the rotary kiln was estimated at 30 minutes at a soil feed rate of 4 tons/h; therefore sampling of treated residue was delayed a similar time duration after initiation of each test run. Each composite sample was then homogenized after which a final aliquot

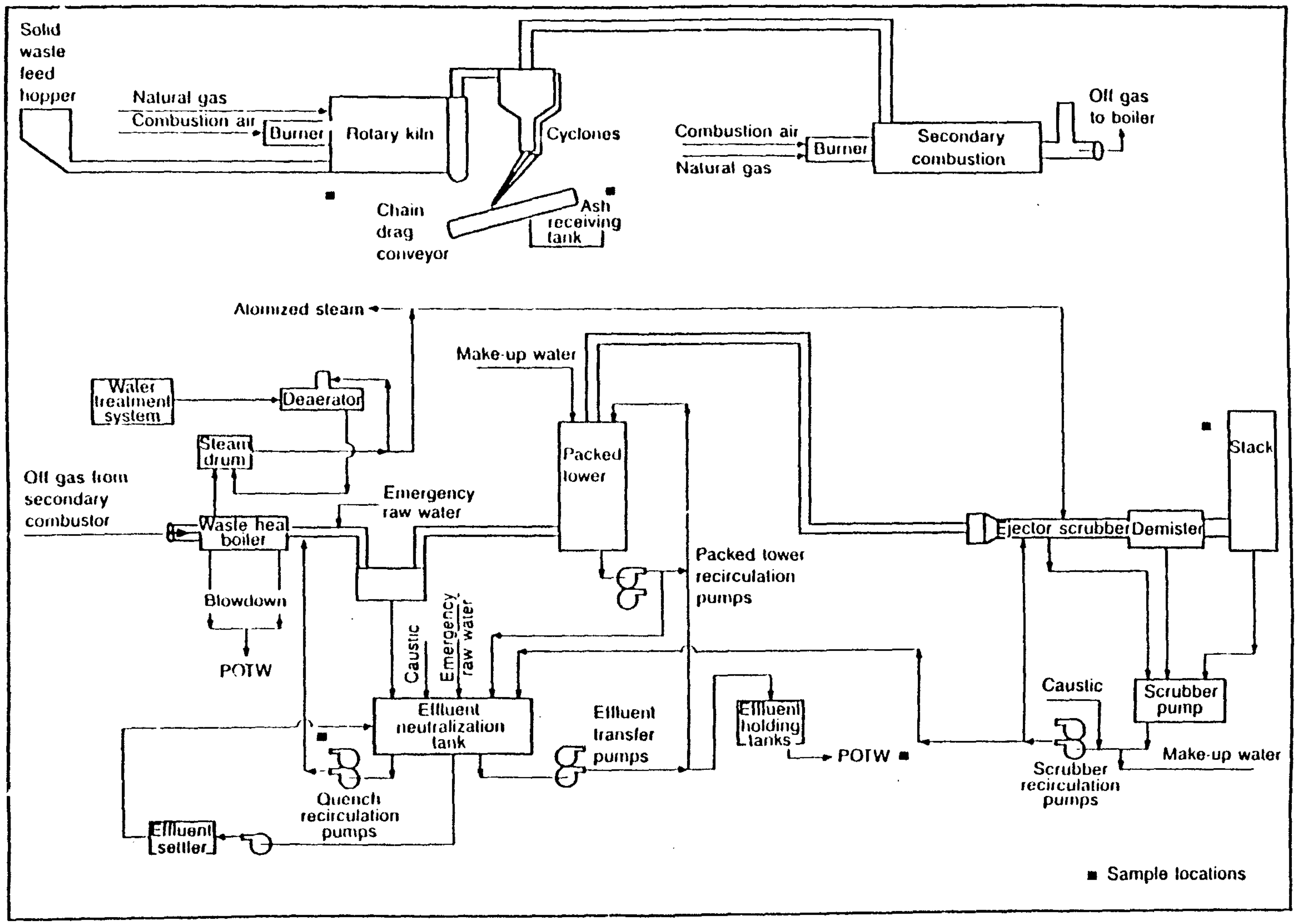

Figure 21. Sample Locations for ENSCO MWP-2000 Incinerator System

sample was taken for analysis. The ash drag solids grab samples were taken from the treated soil in the rolloff box.

The sampling approach for collection of particles and gas samples was to use a Method 5 (M5) and Modified Method 5 (MM5) sample collection system, respectively. Each sample collection system was operated simultaneously. EPA M5 was used for particulate sample collection while MM5 was used for POHC collection. Functionally, the only difference between the two is that an XAD® resin module is placed in the MM5 train upstream of the impingers in order to adsorb the POHC in the gas sample. Although particulates could be measured in the MM5 train, EPA Region IV was concerned that the drying of the particulate filter would drive off some of the POHC collected on it, thus giving a high bias to the DRE calculation. Therefore, the particulate and the POHC had to be measured independently.

Water samples from the ENT were collected after each test run. The water in the ENT is constantly recirculated and thus represented process water used during the entire test run.

Sample collection and handling procedures were in accordance with EPA methods or acceptable protocols current at the time of the tests. Additional details concerning specific sampling methodologies can be found in Reference 2.

6. Sample Shipment

All samples collected during the trial burn were packaged and shipped to the analytical laboratory in accordance with U.S. Department of Transportation regulations. In order to meet time constraints, Federal Express shipped all samples to the laboratory.

7. Analytical Planning

a. POHC Screening

To ensure pure supplies of the two POHCs (1,2,4-TCB and HCE), a sample of each planned surrogate supply was collected, split, and sent to

laboratories at the INEL and ITAS. Subsequent to the analysis, it was determined that schedule delivery problems precluded use of the HCE from the original source used in the screening process. A high purity source was located, and the concentration results for the POHC container samples for each test run were determined for use in the incinerator DRE calculation.

The results from this screening showed that the two POHCs were sufficiently pure to conduct the trial burn. Additional details can be found in Reference 7.

b. Field Samples

Because of the limited objectives of the trial burn, laboratory analysis of soil, water, and stack gas MM5 samples was necessary only for the two surrogate organic compounds, 1,2,4-TCB and HCE. The stack gas M5 samples were also analyzed for hydrochloric acid (HCl) and particulates. High resolution gas chromatograph (HRGC)/high resolution mass spectrometry (HRMS) was required for POHC analyses of the clean feedstock sand and the treated solid residue (ash drag) samples because undetectable concentrations of 1,2,4-TCB and HCE were expected; however, low resolution mass spectrometry (LRMS) was specified for the analyses of neat POHC supply samples because of their procured high concentrations. Required method precision, accuracy, and completeness are listed for each constituent in Table 3. ITAS' analytical procedures were in accordance with EPA methods.

8. Health and Safety

The health and safety plan that was in effect during the verification test burn was also used for the trial burn. A formal change to the health and safety plan was not done for the trial burn; however, the planned operation with the pure surrogate compounds was reviewed for a change in the

TABLE 3. QUALITY ASSURANCE OBJECTIVES FOR SAMPLE ANALYSIS PRECISION, ACCURACY, AND COMPLETENESS FOR MWP-2000 INCINERATOR SYSTEM TRIAL BURN AT NCBC

Constituent	Matrices	Analysis Method	Method[a] Precision	Method[b] Accuracy (percent)	Completeness[c] (percent)
1,2,4-TCB	Soil, water, MM5	GC/MS[d]	28.1	44-142	95
HCE	Soil, water, MM5	GC/MS[d]	24.5	4-113	95
HCl	M5	Titrimetric[e]	<10	--	95
Particulates	M5	Gravimetric	<10	--	95

a. Expressed as standard deviation in µg/L.

b. Expressed as percent recovery.

c Detected, result must be greater than zero.

d. EPA Method 8270, Reference 18.

e. EPA Method 325.3, Reference 20.

protective clothing and equipment requirements for operating personnel. Specifically, persons working with the neat POHC were required to wear Level B protective clothing and respiratory protection, which included the use of disposable encapsulated suits and self-contained breathing apparatuses. Permissible exposure limits (8 hour time weighted average) for 1,2,4-TCB and HCE were 40 and 100 mg/m^3, respectively. Additional details can be found in Reference 7.

K. DELISTING OF PROCESS ASH

According to the EPA regulations described in 40 CFR 260.20, waste containing 2,3,7,8-TCDD or 2,3,7,8-TCDF is classified as an F027 waste. On November 7, 1986, EPA Office of Solid Waste promulgated regulations that effectively banned the land disposal of waste containing dioxins in excess of 1.0 ppb (Reference 8). The regulations permitted disposal of dioxin-containing waste in approved landfills if the dioxin concentration was less than 1.0 ppb; however, there were no approved landfills in the United States accepting dioxin-contaminated waste. This effectively meant that disposal of dioxin-containing waste required processing. However, when such a waste is processed in an EPA approved incinerator, the resulting waste is still considered hazardous and is defined as an F028 waste.

Because the F028 waste is still considered hazardous, it must either be disposed as hazardous waste in an approved Subtitle C landfill or be excluded as a hazardous waste, or "delisted." Delisting is a procedure by which a waste generator may petition the EPA to review applicable data that could be used to determine if a waste meets the regulatory definitions of a hazardous waste. A petition mechanism (to EPA Headquarters) is described in 40 CFR 260.20 and 260.22, which allows persons to demonstrate that a specific waste from a particular site or generating facility should not be regulated as a hazardous waste under 40 CFR 261. To be excluded, petitioners must show that the waste does not meet any of the listed criteria and must also demonstrate that the waste does not exhibit any of the hazardous waste characteristics and does not contain any other toxicants at hazardous levels (Reference 9). If the EPA determines that the waste is no longer hazardous, they will remove that particular waste from their list of hazardous wastes, hence the name, "delisting."

Once an F028 waste is delisted, it may be placed in a Subtitle D type landfill (e.g., a permitted municipal solid waste landfill) or it may be placed back upon the original site. The most economical option for the process ash appeared to be delisting followed by onsite disposal. Therefore, the delisting option was pursued.

As with most regulatory petitions, however, the delisting process undergoes a very long and detailed review cycle. At the time of project initiation, the EPA Office of Solid Waste (OSW) expected the delisting process to take up to two years and they would not grant "up front delisting" (i.e., delisting of the waste prior to analysis of all the processed soil). Also, the delisting process and criteria were not well defined. Furthermore, the delisting authority, which differs from the RD&D permitting authority, could influence the sampling and analysis planning for the verification test burns. Therefore, AFESC and EG&G Idaho project personnel obtained guidance from EPA early in the project to improve the possibility of delisting petition approval when submitted later. If the data from the verification test burn seemed reasonable and if EPA Region IV granted permission to process soil, then the Air Force planned to commence operation and submit a delisting petition at a later date.

In an effort to obtain guidance, a draft delisting petition (along with a copy of the RD&D permit application) was submitted on January 22, 1986, to the (EPA/OSW) in Washington, D.C. (Reference 2). Included was a list of constituents possibly present in the untreated soil at the former HO storage site. The list was developed by scrutinizing the constituents listed in Appendix VIII to 40 CFR 261; those constituents that had no history of usage at NCBC were eliminated from the list. Similarly, many volatile constituents that would have evaporated over the nine year idle period between HO storage and site remediation were also eliminated. The recommended analytical methods and associated detection limits for each constituent were also listed.

In response to a verbal request, additional NCBC sample data were submitted on April 14, 1986. Because the revised RD&D application included a revised sampling and analysis matrix plan, a copy of this plan was transmitted to EPA/OSW in June 1986 seeking verification that the revised plan was acceptable

for the purpose of pursuing delisting. EPA/OSW did not respond during the period of the RD&D application review by EPA Region IV.

EPA/OSW responded to the June request on September 11, 1986. The EPA letter identified polychlorinateddibenzodioxin (PCDD)/polychlorinated-dibenzofuran (PCDF) congeners, chlorinated benzenes, and chlorinated phenols to be on the analysis list. Additionally, EPA recommended a shorter metals analysis list, added the HO constituents and some polycyclic aromatic hydrocarbons, and eliminated coal tars and creosotes.

A meeting was held with OSW in Washington, D.C., on September 19, 1986, to clarify certain details regarding their letter. A representative from Versar, Inc., the subcontractor performing the verification sampling for the project, also attended. Versar, Inc. transmitted a modified sampling and analysis matrix plan to EPA/OSW on October 15, 1986 (Reference 2). This plan included all analyses requested by OSW and several additional analyses to ensure that comprehensive analytical data would be available. The letter also included discussion about methods to achieve low detection limits for PCDDs/PCDFs and organics. OSW confirmed that the modified sampling and analysis matrix plan was satisfactory on December 12, 1986, but added that cyanide/sulfide testing must be included.

As an additional part of the advance delisting process, EG&G Idaho performed a vertical horizontal spread/organic leachate model (VHS/OLM) analysis using the draft model, proposed by the EPA in the Federal Register on February 26, 1985, to determine the proposed delisting criteria. The VHS/OLM model projects the transport of toxicants from disposal sites to nearby receptors. The model is not site specific. The VHS/OLM analysis indicated that delisting was probable if the MWP-2000 incinerator could produce ash with a TCDD concentration less than 0.10 ppb. However, on November 13, 1986 EPA revised the model; subsequent analysis by EG&G Idaho indicated that based on the new model, delisting criteria would be 0.499 parts per trillion (ppt), a factor of 200 lower than the previous level. The new level is approximately a factor of 10 below the limit of detection using high resolution Gas Chromatograph Mass Spectrometry (GCMS) techniques, and a factor of 30 below the limit of practical quantitation set for similar delisting petitions (Reference Federal Register, Volume 53, No 48 page 7903). Fortunately, EPA

recognized this dilemma by stating that "Where hazardous constituents in a waste are determined to be nondetectable using appropriate analytical methods, the Agency will, as a matter of policy, not regulate the waste as hazardous." Therefore, it was incumbent upon the Air Force to show that no TCDD could be detected in the processed soil using approved methodologies.

Once routine operations began at NCBC in November, 1987, EG&G Idaho began collecting data to support a delisting petition. Every month a comprehensive ash sample was collected over a 24-hour period. Initially, the ash sample was collected from the ash storage rolloff boxes located approximately 100 yards from the incinerator. In an effort to minimize the potential for cross-contamination of native soil with processed ash, samples were collected directly from the ash drag beginning in April, 1988.

In November, 1988, a delisting petition was submitted to the EPA OSW. That petition included data from monthly comprehensive samples for the months of December, 1987 through July, 1988. In March 1989, an addendum report was submitted to EPA/OSW that included data collected from August, 1988 to the end of the project in November, 1988. The addendum report also included responses to some informal questions that were received from EPA contractors responsible for reviewing the petition.

The data showed that for the 36 samples submitted, no valid sample showed any measurable TCDD equivalent in excess of 15.0 ppt; that level is deemed by many scientists to be the limit of reliable or practical quantitation. Seven samples showed TCDD equivalent in concentrations in excess of 9.0 ppt (but less than 15.0 ppt). EPA had previously considered such levels to be equivalent to a nondetectable concentration for an "up-front" delisting petition on an EPA incinerator. However, for data submitted after the remedial action was completed, EPA was more stringent.

In November, 1989 EPA verbally indicated to the Air Force and EPA Region IV that delisting was unlikely and suggested that the Air Force withdraw the petition. At the time of the writing of this report, the Air Force had not withdrawn the petition and the disagreement had not been resolved.

L. SITE CLOSURE

The goal of site closure is to return the former herbicide storage area to the Navy for beneficial use. Since the removal of the bulk quantities of HO, the Navy has not used the site due to the presence of dioxin contamination; it has remained a vacant field. The Navy intends to use the land for the construction of warehouses and open storage areas for military material.

To return the site to beneficial use, the Air Force and Navy discussed the requirements with the State of Mississippi Department of Natural Resources and EPA Region IV. In October, 1988, all concerned parties agreed to the following general plan for returning the site to the Navy for beneficial use:

1. The Navy, with support from the Air Force, would proceed with Installation Restoration Program documentation of the investigation and remedial actions occurring at NCBC. That documentation was to be consistent with the National Contingency Plan.

2. The Air Force and the Navy would jointly write a decision document consistent with the Navy's Installation Restoration Program. That document was intended to demonstrate the site cleanliness and to demonstrate that no additional remedial action at the former HO storage site was necessary.

To achieve the state objective, EG&G Idaho, prepared a draft decision document that: (1) documented the site history, (2) showed that the final concentration of all remediated and unremediated plots was less than 1.0 ppb of 2,3,7,8-TCDD, (3) included a groundwater and risk assessment model that demonstrated the risks to a potentially exposed individual were minimal.

The draft decision document assumed that the process ash would be delisted, which meant that no hazardous waste remained on the site. As mentioned previously, in November, 1989 EPA/OSW informally indicated that delisting was not likely, therefore, the closure decision document strategy became ambiguous. The State of Mississippi Department of Natural Resources and EPA Region IV became concerned over the fate of the processed soil that was stored on the site. As a result, the closure plan was expanded to include

groundwater monitoring and additional groundwater modeling which would include the process ash as part of the source term. The revised strategy also included provisions for additional sampling of the soil from the remediated site. At press time for this report, no decision concerning final site disposition has been reached.

M. PERMIT APPROVAL PROCESS

This section describes the additional data transmittals and communications between EPA Region IV, the Air Force, and the Air Force contractors that were necessary to obtain an operating permit.

As described previously in Section III.C, an application for an RD&D permit was submitted in January, 1986. The permit to begin testing was granted by EPA in July 1986. The required verification test burn was conducted in December, 1986. The data from the verification test burn were reported in January, 1987, at which time EPA informed the AFESC of the need to perform a RCRA Trial Burn (See Section III.J.1).

1. RCRA Trial Burn Reporting

The trial burn was performed in May, 1987. On June 9, 1987, the Air Force received a formal request from EPA Region IV concerning a variety of technical issues including clarification of the SCC gas retention time calculation, the mass feed rate calculation, and clarification of the use of the thermal relief valve. The letter also requested that the Air Force develop a comprehensive ambient air monitoring program. A considerable amount of time was expended in the development of the SCC retention time and mass feed rate calculations because they had not been previously developed adequately by ENSCO. Additional details can be found in Reference 7.

Following the trial burn in May, 1987 EG&G Idaho wrote a trial burn report with the assistance of Versar and the Air Force. ENSCO also provided some technical information for the report. Before commencement of extensive work on the report, EG&G Idaho discussed the report outline with the persons within EPA Region IV who would review the report. Once an outline was agreed upon, a draft trial burn report was submitted to EPA Region IV on June 16,

1987. The transmittal letter requested that EPA quickly review the report for format and general content. This request was made to again ensure that the report authors were working in a direction that was compatible with EPA needs and requirements. EG&G Idaho was also striving to present a report that would be easy for the regulating agencies to review in the hopes of expediting the review process.

EPA carefully reviewed the draft report and submitted verbal comments to EG&G Idaho in early July, 1987. The comments were incorporated and the final trial burn report was submitted to EPA Region IV on July 15, 1987, eight weeks after the completion of the trial burn. EPA Region IV subcontracted much of the technical review.

In August, 1987 EPA Region IV submitted their formal comments concerning the trial burn report to the Air Force. Most of those comments requested additional information or clarification concerning quality assurance issues. EPA Region IV agreed that the MWP-2000 had passed the 99.9999% DRE requirement, however, they were still uncertain on what permit operating conditions to set. In particular, the issue of how to accurately measure and regulate the mass feed rate was raised again. All of these comments except the mass feed rate were addressed and a formal response was submitted to EPA Region IV on September 9, 1987.

In late September, 1987 an attempt was made to correlate the mass feed rate measured by the weigh hopper and the DAS to the feed auger speed. It was believed that a maximum auger speed limit could be used to ensure that contaminated soil would not be fed to the incinerator in excess of the rate observed during the trial burn. No accurate correlation was possible because of variability in soil moisture and density. EPA Region IV, after examining the data, verbally agreed to set the mass feed rate at 5.3 tons/h, based upon the weigh hopper load cells and the DAS. However, EPA Region IV also stipulated that the Air Force would attempt another such correlation after the commencement of operations, when additional data were available; subsequent correlations were also to no avail and EPA agreed to set the feed rate at 5.3 tons/h, based on the existing load cell and DAS system.

2. Ambient Air Monitoring Plan

To satisfy the EPA request for an ambient air monitoring plan, EG&G Idaho submitted a draft plan on September 2, 1987. EPA reviewed the plan and provided verbal comments in several telephone conversations in September, 1987. A final ambient air monitoring plan was submitted on October 7, 1987. Details of the plan can be found in Reference 4.

3. SCC Gas Residence Time

The SCC gas residence time provides data with which to assess the completeness of combustion of the process off-gases. During the trial burn, the residence time was measured by the DAS as a function of: (1) the total natural gas flow rate, (2) SCC and kiln combustion air flow rates, (3) SCC and kiln temperature, (4) soil feed rate, and (5) the volume of the SCC. That calculation also contained certain invalid assumptions. The clarification request made by EPA on June 9, 1987 prompted a review of the original residence time equation. ENSCO then submitted a revised equation. Although that equation was an improvement over the original, it still contained certain unverified and unmeasurable terms. A second evaluation of the equation resulted in a substantially different equation that did not have unmeasurable or unverified assumptions. The final equation was a function of: (1) the kiln and SCC temperatures, (2) the kiln and SCC natural gas flow rates, (3) the stack gas oxygen content, (4) the solids feed rate, and (5) the soil moisture content.

Process data for those parameters were resubmitted to EPA along with the revised equation for calculating residence time. Based upon that data, EPA set the SCC residence time at 1.65 seconds, slightly higher than the 1.60 second minimum time observed during the trial burn.

The development or presentation of the final residence time equation is beyond the scope of this report. The equation is given in Reference 7 and developed in Appendix W of Reference 7.

4. Ash Disposition

Because the processed soil is considered an F028 listed waste, it had to be either delisted or landfilled (See Section III.K.). At the beginning of the project, in early 1986, the Air Force recognized that the delisting regulations could seriously impact the disposition of the processed ash. Therefore, the Air Force negotiated an agreement with the EPA Region IV regional administrator that allowed the process ash to be backfilled onsite before the submission of a delisting petition. To backfill the ash, the concentration of TCDD, total chlorinated dioxins, and total chlorinated furans had to be measured and determined to be each less than 1.0 ppb. Specific conditions were set for collection and sampling of the ash. If the batch did not meet the criteria, then it was to be reprocessed in the incinerator.

The ash was to be stored in 20 yd^3 rolloff boxes while awaiting sampling results. Following the trial burn, project personnel realized that the volume of process ash expected to be produced far exceeded the number of rolloff boxes available. Therefore, an alternate ash storage arrangement was developed that would employ ash bins constructed of railroad ties and lined with heavy plastic. EPA determined this to be a major permit modification and indicated that a 45 day public comment period would be necessary. Due to time constraints, the Air Force withdrew the plan and located additional rolloff boxes.

After all of the trial burn questions were resolved and the incinerator operating conditions were set, EPA staff began to question the ash backfilling plans and suggested that such action would not be permitted because the processed soil was considered an F028 listed waste. The Air Force and its contractors evaluated several options, including a large storage bunker for the process ash, but quickly concluded that storing such a volume of soil until a delisting determination was made by the EPA Office of Solid Waste would be financially infeasible.

Additionally, EPA Region IV staff began to examine the analytical requirements for the processed soil and requested that the Air Force perform a multitude of additional organic and inorganic analyses including daily high resolution analyses for all congeners of dioxin. This proposal would have

significantly inflated the cost of the project. These issues were at a stalemate between the Air Force contractors and the EPA Region IV staff. Therefore, the Air Force project officer met with the EPA Region IV administrator to negotiate a compromise. That meeting resulted in continued permission to backfill the treated soil if analysis demonstrated that the 2,3,7,8-TCDD, total TCDD, and total TCDF concentrations were below 1.0 ppb. Additionally, the Air Force agreed to perform a comprehensive analysis on a 24-hour composite sample collected once per month.

5. Resulting RD&D Permit Conditions

As a result of the data from the trial burn and the ensuing communications and negotiations, EPA Region IV set the operating conditions for the NCBC Demonstration Project. Those operating conditions are summarized in Table 4. The complete permit is given in Reference 2.

TABLE 4. NCBC DEMONSTRATION PROJECT FINAL RD&D PERMIT OPERATING CONDITIONS SUMMARY (AS OF NOVEMBER 23, 1987)

- The incinerator must meet a 99.9999% Destruction and Removal Efficiency.
- Hydrogen chloride (HCl) emission rate must be less than 1.8 kg/h or 1% of the HCl in the stack gas prior to entering any pollution control equipment.
- Particulate matter must not exceed 180 milligrams per dry standard cubic meter corrected to 7% oxygen.

• Mass feed rate	< 5.3 tons/h
• Kiln temperature	> 1450°F
• SCC temperature	> 2150°F
• SCC retention time	> 1.65 s
• Stack carbon monoxide	cannot exceed 50 ppm for more than 6 minutes
	< 500 ppm maximum at all times
• Maximum auger speed	5.8 rpm
• Packed tower recirculation flowrate	> 132 gallons/minute
• Ejector scrubber recirculation flowrate	> 35 gallons/minute

TABLE 4. NCBC DEMONSTRATION PROJECT FINAL RD&D PERMIT OPERATING CONDITIONS SUMMARY (AS OF NOVEMBER 23, 1987) (CONCLUDED)

• Kiln pressure	Cannot exceed -0.05 inches of water for more than 15 seconds
• Thermal relief valve	To be opened only under emergency conditions when steam drum water level is at 0%, or the waste heat boiler exit temperature exceeds 600°F or the packed tower inlet temperature exceeds 220°F. SCC temperature must be maintained for approximately 20 minutes with the kiln rotation at 4.5 rpm or until all material in the kiln is removed.

- A report attempting to correlate the bulk average feed rate to the auger speed for the first 14 days of operation shall be submitted to the regional administrator.

- Ambient air shall be monitored per the ambient air monitoring plan until the regional administrator approves of proposed changes to be submitted approximately 30 days after the startup of operation.

- Soil moisture must be measured via an infrared analyzer or ASTM method 02216-80 and the data shall be input to the DAS each 8 hour shift. A correlation shall be drawn between the automatic infrared analyzer system and the American Society for Testing of Materials (ASTM) method and reported to the regional administrator within 5 days of commencement of operation.

SECTION IV
FIELD OPERATIONS

This section summarizes the field activities described in the other volumes of this report and includes conclusions and recommendations from each volume.

A. VERIFICATION TEST BURNS

1. Discussion

The overall plan for the MWP-2000 verification test burns included: (1) incinerator setup and checkout, (2) soil preparation and handling, and (3) incinerator operation. Approximately 270 tons of clean and contaminated soil were planned to be processed during the verification test burns. EG&G Idaho/AFESC project management designated the soil excavation locations for contaminated soil based on results of surface soil sampling. Soil with the highest known contamination levels was used to best demonstrate the capabilities of the treatment technology.

The goals of the verification test burns included the following:

- to determine if the MWP-2000 can reduce the concentrations of tetra-, penta-, and hexachlorodibenzo-p-dioxins and the tetra-, penta-, and hexachlorodibenzo furans to levels less than 1 ppb. Additionally, it was desirable to reduce the level of those chemicals listed in Appendix A of the RD&D Permit application to levels acceptable for "delisting" of the treated soil under the Resource Conservation and Recovery Act.

- to verify whether the incinerator was capable of processing the cement-stabilized soil without producing additional listed or characteristic hazardous waste.

- to ensure that the operation of the incinerator does not cause any adverse effects to human health or the environment.

One or more tests at each of the following feed rates were planned to provide data for an operating range within the MWP-2000 capacity: (1) 3 tons/hr, (2) 4 tons/hr, a d (3) 4.5-5.0 tons/hr. Gas outlet temperatures for the rotary kiln and the secondary combustion chamber were planned at 1600-1800°F and 2150°F, respectively. The planned approach was to reach operating conditions and operate with clean soil (approximately 240 tons) for 3 days continuous operation and then follow with individual contaminated soil test runs. Periods of standby operation (no soil being fed) were phased between the initial clean soil checkout and the different tests in order to provide distinct identification for process sampling.

Five verification test burns were conducted and evaluated for a range of operating conditions. One hundred tons of contaminated soil were processed during these five verification test burns. Soil feed rates ranged between 2.8 and 6.3 tons/h. Average kiln temperatures varied between 1,355 and 1,645°F. The SCC average temperatures varied between 2,097 and 2,174°F.

Samples of feedstock, treated soil, stack gas, liquid waste effluent, and ambient air were taken by rsar, Inc. of Springfield, Virginia for each test burn and sent to IT Analytical Services of Knoxville, Tennessee for analysis. The stack sampling system consisted of EPA Modified Method 5 and Volatile Organic Sampling Train (VOST). Laboratory methods and protocols were drawn from EPA CLP procedures. The analytical results were independently evaluated within method/protocol requirements and were found acceptable.

2. Soil Treatment

All test burns achieved the AFESC goal that the treated soil PCDD/PCDF congener sum (tetra, penta, and hexa) be less than 1.0 ppb. The congener sum ranged from 0.009 to 0.021 ppb with the maximum concentration occurring for a test burn during conditions of lowest average kiln temperature (1,355°F) and highest average soil feed rate (6.3 tons/h).

Soil-to-ash removal efficiency (SARE) is defined as:

$$\text{SARE} = \frac{(\text{mass TCDD in feedstock soil}) - (\text{mass TCDD in process ash})}{\text{mass of TCDD in feedstock soil}}$$

SAREs of at least four 9s were achieved for 2,3,7,8-TCDD and total TCDD. The calculated soil SAREs ranged between 99.9921 and 99.9966% for 2,3,7,8-TCDD and between 99.9952 and 99.9984% for total TCDD. In all cases these represent lower bounds because neither of the species was detected in any of the treated soil samples, and the detection limit values (DLV) for high resolution gas spectrometry (HRMS) were used in the calculations.

Calculated SAREs of five 9s for two of the test burns and four 9s for the other three test burns were achieved for 2,4,5-T. The SAREs ranged between 99.9957 and 99.9998%. In all cases these represent lower bounds because 2,4,5-T was not detected and the DLV (2 ppb) was used in the calculations. Most significantly, the highest SARE was obtained during the test burn of lowest average kiln temperature and highest average soil feed rate. If lower DLVs were used, it is likely that SAREs of the six 9s for 2,4,5-T would have been realized.

While 2,4-D was not detected in the treated soil (DLV of 20 ppb), the SARE results for the herbicide were lower than for 2,4,5-T with a range between 99.9130 and 99.9994%. This was due to lower 2,4-D concentrations in the feedstock soil samples and higher DLV (factor of 10) in the treated soil samples.

Cleanup of 2,4,5-trichlorophenol, observed in the feedstock soil samples, occurred; however, the reduction evaluation was limited because of low initial concentrations and high DLVs. The best example observed showed a concentration of 0.21 ppm in the treated soil sample where the concentration in the feedstock soil sample for the same test burn was 8.8 ppm.

Although only found in the ppb range in the feedstock samples, some reduction in concentrations for three polynuclear aromatic hydrocarbons (PAH) [fluoranthene, benzo(b)fluoranthene, and benzo(a)pyrene] was observed. The best sample was the reduction of fluoranthene in the feedstock soil sample of one test burn at 110 ppb to a concentration of 2.7 ppb in the treated soil sample.

Within the variability of individual analyses, there were no observed concentration differences of any significance for metals between feedstock and treated soil samples.

The treated soil produced by the incinerator process for NCBC HO-contaminated soil was evaluated for delistability to EPA requirements. Because the treated soil is not corrosive, ignitable, or reactive, and because it passes the requirements for the Extraction Procedure (EP) Toxicity Test, the requirements of 40 CFR 261.21-261.24 can be satisfied. The hazardousness of the contaminated soil can be reduced to concentrations of dioxins that are significantly less than 1.0 ppb, so that if delisting failed, the EPA rules for landfill disposal of dioxin-contaminated material could still be met. The concentrations of the HO-related organics detected in the feedstock above 1 ppm were removed to nondetectable levels well below 1 ppm in the treated soil. The concentration of 2,3,7,8-TCDD in the processed soil was nondetectable using high resolution GC/MS techniques with a DLV of 1.1 ppt; therefore, the processed soil should meet the delisting criteria established via the VHS/OLM models specified in 51 CFR 41082-4100 (Reference 2). At the conclusion of the verification test burn, delisting appeared plausible, however, EPA OSW would not make a delisting determination at that time.

3. Incinerator Performance

The MWP-2000 incinerator system demonstrated that two of the three performance standards could be met. These were chloride and particulate emissions. Sample analysis of stack gas showed chloride concentrations of 0.29 μ/m^3 or less for all test burns, which is well below the EPA limit of 1.8 kg/h in 40 CFR 264.343(b). Also particulate concentrations were 49.7 mg/dscm or less for all test burns, which is well below the limit of 180 mg/dscm in 40 CFR 264.343(c).

The DRE of 2,3,7,8-TCDD could not be demonstrated by the process because the dioxin concentration in the HO-contaminated soil was not sufficiently high to be able to calculate a DRE meeting the EPA limit of six 9s in 40 CFR 264.343(a). No 2,3,7,8-TCDD was detected in the stack gas samples and HRMS was used to achieve lowest possible detection levels

(0.22-0.32 ng/m^3). Four 9s were demonstrated ranging from 99.9968 to 99.9985%.

Destruction and removal efficiencies of six 9s were demonstrated for the herbicides 2,4-D and 2,4,5-T on at least one test burn. Because of its higher initial concentrations in the HO-contaminated soil and lower analytical detection level (factor of 10), the DRE results were better for 2,4,5-T than for 2,4-D with a range of 99.9968 to 99.9999%. Two test burns met six 9s; however, EPA recommends that this requirement be met by three test burns (Reference 2). The 2,4-D range was 99.9736 to 99.9999% with one test burn having a DRE of six 9s. Because neither of the herbicides was detected in the gas samples, the DLVs were used in the DRE calculations giving a lower bound value. One of the test burns showing a DRE of six 9s for 2,4,5-T occurred during the most severe operating conditions among the five test burns. The herbicide DRE results provide a significant indication of the incinerator system capability to meet the EPA DRE performance requirements for POHCs.

4. Liquid Waste Effluents

For the feedstock conditions that prevailed during the test burns, the incinerator process demonstrated that the liquid effluent waste generated during the operations was nonhazardous. No 2,3,7,8-TCDD, 2,4-D or 2,4,5-T was detected in the composite sample of the liquid waste stored for subsequent release to the NCBC sewer line for POTW treatment, which also satisfied the POTW permit issued by the State of Mississippi for the project. The detection levels were well below EPA requirements where a standard existed. Detected metals in the liquid waste were at concentrations well within EP Toxicity Test limits.

5. Ambient Air Quality

During all phases of operation monitored by ambient air sampling, the particulate concentrations were shown to be quite low (less than 0.11 mg/m^3 average concentration for any sample) compared to the TLV for total dust at 10 mg/m^3. Ambient levels of 2,4-D and 2,4,5-T were also shown to be very low, being six orders of magnitude below the TLV of 10 mg/m^3 that applies

for both compounds. These results demonstrate that the activities associated with this soil restoration process can be done safely.

6. Problems Encountered

During testing numerous mechanical problems occurred that affected not only the verification test burns, but subsequently impacted soil processing later. All of the problems were either mechanical or personnel-related rather than a technological failure of the incinerator system.

a. Shredder

Several costly equipment problems occurred during setup and thermal testing. The hydraulic shredder motor seized soon after it was initially tested on clean soil. Because it was a used shredder and not domestically made, locating spare parts caused a two day delay. Once the shredder was fixed, however, no significant problems were observed until routine operations began the following year.

b. Particulate Cary-over

Particulate carry-over from the kiln, through the SCC, and onto the boiler face place caused a lot of initial problems. The buildup restricted the off-gas flow and decreased the ability of the jet scrubber to draw the gases through the incinerator system. A long term solution to this problem did not become apparent until the second month of routine soil processing. During the verification test burn, several days were lost when the system had to be cooled down to remove the particulate buildup.

c. Wast Heat Boiler

The waste heat boiler also became clogged from molten silica condensing and forming a glassy surface on the inside of the boiler tubes[1]. The silica source was the native NCBC soil, which contains large quantities of sand. This condensed silica significantly restricted the gas flow through the boiler. To remove the silica, the incinerator was cooled down, the face plate on the end of the boiler was removed and each tube was reamed out with a mechanical "bottle brush" type device. This process cost approximately 2 days of testing.

Cleaning of the boiler, resulting from the particulate carryover proved to be awkward to perform and operationally time consuming. Redesign of the boiler end plate could improve this situation.

To prevent the silica from condensing, a water spray was installed upstream of the boiler in the crossover tee section. The water spray, when activated, would condense the silica into a solid form before it condensed onto the boiler tubes. As a particulate, most of the silica was able to travel through the boiler and be collected in the pollution control system downstream. Some silica particles still deposited in the boiler tubes; however, because it was a particulate, it was much easier to remove.

On one occasion, during clean soil operation, the incinerator operator had difficulty in maintaining the system draft. The operator turned off the water spray in an effort to reduce the heat loss to the boiler, which theoretically would have increased the steam generation rate and the available draft at the jet scrubber. Unfortunately, by turning off the water jets to the crossover tee section, the silica condensation problem reappeared and the boiler became plugged. A day of testing was lost while the boiler was cleaned again. A clearer understanding of the overall processes involved, adherence

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1. Note that this silica problem occurred on the inside of the boiler tubes and is not the same as the dissolved silica problem discussed above that impacted the outside of the boiler tubes as described in Section III.6.2.

to procedures, and communication of the problems to other technical personnel could have averted the blockage.

d. Soil Feed System

Three significant problems were associated with the soil feed system: (1) moist soil bridging above the rotary auger in the feed hopper, (2) shredder reliability due to the nature of the cement-stabilized NCBC soil, and (3) determination and control of mass feed rate. The third problem was resolved by installing electronic load cells on the weigh hopper and transmitting the signals to the data acquisition system; however, adequacy of this solution was demonstrated during the soil restoration phase of the project. The other problems require long-term resolution.

e. Cyclone separator

Improper design of the cyclone separator caused significant quantities of particulate to be carried over from the kiln into the SCC. That particulate was then carried into the boiler where it plated out onto the boiler faceplate and into the boiler fire tubes. A partial resolution was made during the test burns to increase the air velocities in the cyclone by blocking off one of the two parallel cyclones. A longer vortex tube is needed. An additional problem was that particulate tended to collect within the cyclone rather than fall downwards by gravity to the ash drag as intended.

f. Operator Awareness

Review of SCC temperature records shows that improved incinerator process operator awareness is needed to maintain good temperature control. Cases were noted where initial temperatures were manually set too close to limits that could activate automatic trips and where temperature drifting occurred without response for substantial time, thus also causing temperatures to reach limits activating automatic trips. This may have been caused, in part, to inexperience at the beginning of the project and variability within the NCBC feedstock.

7. Verification Test Burn Recommendations

a. Based on the analytical data from the verification test burns, the MWP-2000 incinerator process should be considered as an acceptable technology for treating dioxin-contaminated soils at relatively high feed rates (5-6 tons/h). This technology can process soil and other inorganic solids with little pretreatment and with the use of conventional equipment.

b. The MWP-2000 incinerator process also should be considered as a technology for detoxifying soils contaminated with other organic compounds.

c. Because the DRE performance for 2,3,7,8-TCDD could not be demonstrated because of low concentrations in the feedstock, it was required that trial burn testing at NCBC be performed with surrogates acceptable to the EPA to demonstrate six 9s DRE.

d. It was recommended that the problems identified as a result of this testing be investigated by ENSCO for possible design and/or procedural changes that would improve the system operability and reliability.

e. At the beginning of a restoration project, there should be emphasis on supervision and training of system operators to ensure understanding and awareness of control responsiveness, especially to avoid reaching operating limits that require mitigating actions.

f. Schedules of restoration tests should include allowances for seasonal weather conditions. In areas such as the Gulf Region, where weather changes can occur suddenly, it is advisable to plan for only one test during any operational day. Also, twice as many days should be scheduled as there are stack tests to be performed.

g. Documented RCRA certification status of any restoration technology process should be clearly made known to the contracting agency of a restoration project prior to committing to field activities. This includes making known any process configuration or procedural changes that might invalidate an existing RCRA certification and cause undue delays because of subsequent interactions required with the EPA Regional Office having administrative jurisdiction over the project.

B. TRIAL BURN TESTS

1. Discussion

The overall plan for the MWP-2000 incinerator system trial burn was to conduct the following activities over approximately a 25-day span: (1) start up system, (2) conduct clean soil test, (3) blend a surrogate contaminant into clean sand feedstock, (4) conduct two tests, each with three replicate performances, and (5) shutdown the system. The first test was planned for nominal feed rate operation at 4 tons/h. The second test was planned for nominal feed rate operation at 5 tons/h. Approximately 300 tons of clean commercial sand spiked with the hexachlorethane (HCE) and 1,2,4-trichlorobenzene (TCB) as surrogate contaminates were used. Section III.J.2 describes the surrogate selection.

The amounts of HCE and TCB to be injected were planned to provide concentrations of each POHC in the range 1,500 to 3,000 ppm. The objective of each test was to demonstrate greater than six 9s DRE for the dioxin surrogates, as well as satisfy the particulate and HCl emissions limits.

The onsite activities supporting the trial burn began in late April 1987 with the arrival of the ENSCO and Versar personnel teams and representatives from EG&G Idaho and AFESC.

On April 30, 1987, the incinerator system was started up to produce steam. Clean sand was used as feed. No significant problems were encountered with the initial startup. The incinerator system was again operated on May 2, 4, and 5 to obtain background samples. Following this, a readiness review was

conducted by the representatives and key personnel from the project organizations. This consisted of reviewing a checklist of activity steps and documentation necessary to start up the incinerator system for the trial burn from the previous cold standby status left from the verification test burns in December 1986.

Preparation of the POHC-spiked sand feedstock was started on April 30. The POHC and sand mixture was mixed in a cement mixer with samples taken at hourly intervals. Analysis of the mixture showed that the POHC concentration was approximately one fourth of the calculated concentration. This was true regardless of the mixing time. The POHC apparently volatilized during the mixing process.

An alternate method used POHC, mixed with cotton seed hulls, which were in turn mixed with the sand in the cement mixer. It was quickly apparent that this method would also fail because the cotton seed hulls floated to the top of the sand during mixing.

Finally, after these methods proved fruitless, EPA Region IV suggested that the POHC be placed in containers that could be dropped into the waste feed at discrete intervals. This method had been previously suggested by the Air Force contractors but rejected by EPA.

In the alternate method, discrete quantities (1.5 pounds nominal) of the pure POHC were placed in polyethylene containers (sample bottle for 1,2,4-TCB; Ziploc® baggie for HCE). The containers were then placed in the kiln feed hopper on a regular interval (every 3 minutes) throughout each test run. This alternative method of feeding the surrogate compounds to the process provided a higher degree of assurance that the POHC would enter the incinerator, while reducing the chance of inhalation or cross-contamination in the vicinity of the feed hopper. The POHC was introduced into the kiln at least 45 minutes before the stack test to ensure system equilibration with POHC.

Verbal permission to begin testing was received from the EPA on May 7, 1989. On May 8, an EPA representative returned to the site to witness the first trial burn tests; however, weather conditions (lightning) developed

such that sampling personnel could not safely perform on the stack, and the run was terminated between the first and second stack sample traverses. Attempts were also made on May 9 and 10, but gas sampler leakage problems and weather conditions precluded any test runs being performed. Leakage problems were caused by faulty seals at a flange and a quick disconnect; these were corrected. Following a successful leak check on May 11, Test Run 7A was performed without any notable or unusual events. Test Run 7B followed on May 12, also without any unusual events.

The test run on May 13 was voided because of an incorrect equipment configuration alignment. The condenser was inadvertently placed downstream of the XAD® resin column, which precluded proper cooling of the gas stream ahead of the filter. A test run was started on May 14, but weather conditions forced an early termination because of personnel safety on the stack.

The final run, Test 7C, was performed on May 16. All three test runs were made at approximately the same operating parameters to provide a triplicate replication.

The test plan originally called for two sets of tests: (1) one test set was planned for 4 tons/h and, (2) another for a maximum feed rate of 6 tons/h. Run 7A was actually run at 5.1 tons/h. This higher than planned feed rate was caused by operator inexperience and manual calculation of the feed rate. The lightning storm on May 10 caused some electronic damage to the weigh hopper load cells, which resulted in an erroneous feed rate. As a result, it was decided to run Test 7B at the same conditions as Run 7A. The samples were sent to IT Laboratories for analysis. Preliminary results were received on Friday, May 15. The results of those tests indicated that the MWP-2000 had passed the six 9s DRE requirements. Therefore, it was decided to perform Run 7C at the same test conditions to complete the required triplicate test. Had Run 7A or 7B failed, then the incinerator operating conditions would have been changed to increase the chances of success.

The second series of tests--Runs 8A, 8B, and 8C--that were planned for the maximum possible feed rate were canceled. The numerous problems and schedule delays encountered during Test 7 indicated that a substantial effort would be required to successfully complete Test 8. Additionally, operations

personnel observed that, based upon the verification test burns in December 1986 and the operating experience gained during these trial burns, consistently higher feed rates above 5.3 tons/h were not likely. The cost and effort to complete a higher feed rate test did not justify the unlikely potential benefits.

Following the final trial burn run, the MWP-2000 incinerator system was shut down and placed in cold standby to await EPA authorization to commence routine operations for soil restoration at the site. Because analyzing the collected samples, evaluating, and presenting the data to EPA Region IV, and subsequent AFESC/EG&G Idaho interacting with the regulatory agency could involve a considerable period of time, the ENSCO crew was reduced to a size sufficient for security and maintenance.

2. Trial Burn Conclusions

Specific conclusions concerning the incinerator process performance and operational problems during the trial burn test follow.

a. The MWP-2000 exceeds the incinerator performance requirements specified in 40 CFR 264.343. Specifically:

- DRE was shown to exceed 99.99996%. The highest DRE observed was 99.999979%.

  Higher DREs may have been possible if lower stack gas analytical detection limits were used. The DRE required to process F027 contaminated waste is 99.9999%.

- The highest particulate concentration observed was 68.28 mg/dscm. The RCRA requirements specify that the particulate concentration be less than 180 mg/dscm. Therefore, the MWP-2000 incinerator surpassed the particulate emissions standard by at least a factor of 2.6.

- The highest hydrogen chloride (HCl) emission rate for these tests was 0.121 kg/h. The applicable standard requires that the HCl emissions be less than 1.8 kg/h or less than 1% of the HCl input to the scrubber system. Therefore, the MWP-2000 surpassed the HCl requirements by a factor of 14.8 when processing the surrogate mixture. The chlorine loading during the trial burns was significantly higher than the chlorine loading projected for routine operations.

b. Numerous problems were encountered during the trial burn and its preparation. Notably, the originally planned POHC mixing technique was abandoned for direct addition of POHC to the incinerator. Problems encountered during sampling centered around failure of MM5 leak checks. All of the problems encountered were either personnel related or mechanical failures rather than a technical failure of the incinerator system.

3. Trial Burn Recommendations

a. This trial burn was required to demonstrate compliance with 40 CFR 27.343. In early 1936, ENSCO performed a trial burn on an identical unit located in El Dorado, Arkansas. The data from those tests were intended to be used by the Air Force in lieu of a trial burn at NCBC; the verification tests burns conducted in December 1986 at NCBC were only intended to demonstrate that no hazardous effluents would be emitted from the MWP-2000 when processing native contaminated NCBC soil. When EPA Region VII did not certify the El Dorado trial burns as meeting the 99.9999% DRE requirement, EPA Region IV justifiably required that the Air Force demonstrate DRE compliance before operations.

Therefore, future users of hazardous waste technologies are reminded to carefully examine certification data and to verify with the appropriate regulating agencies that the technology meets all applicable requirements. If the chosen technology does not meet the requirements, then the users should be prepared for extensive testing, technology development, and regulatory involvement.

b. The redevelopment of the residence time equation caused considerable delays in obtaining regulatory approval to commence operations. Therefore, when submitting a trial burn plan, all data that will be used to set operating parameters for normal operations should be clearly defined before testing.

For example, the method of calculating residence time was inadequately developed at the time of the trial burn. The residence time calculated during the tests was highly inaccurate and only coincidentally represented the actual SCC residence time. The inadequacy was not discovered and corrected until the trial burn report was thoroughly reviewed. Although data existed that enabled project personnel to recalculate the residence time, critical data needed for the calculation might not have been measured.

Because residence time is a critical operating parameter, such an oversight could have caused the complete failure of the trial burn test results.

c. Measurement of solids feed to an incinerator or other processes can be accomplished in a variety of ways. The method used at NCBC employed load cells that measured the weight of a hopper at a given time. The DAS differentiated with respect to time those data to obtain a mass feed rate. At the time of testing, project personnel and EPA regulatory personnel had a poor understanding of the data collection and differentiation system used. As a result, there was a considerable delay following the trial burn to properly explain and present the mass feed rate data.

Future users of this technology are encouraged to understand and thoroughly test the mass feed system and its measurement and controlling devices.

d. The POHCs used for the NCBC trial burn were 1,2,4-trichlorobenzene and hexachloroethane. Those POHCs served the purpose very well and were reasonably easy to handle. HCE, however, is an Appendix VIII listed hazardous waste, therefore, the ash resulting from the trial burns was also considered a listed hazardous waste. Future trial burn planners are encouraged to obtain a POHC that meets the technical requirements of the

planned test, and that will not result in a hazardous waste when processed. Substantial residue disposal costs or delisting documentation costs could be saved if the product were not hazardous.

e. Introduction of the POHC to the incinerator is an integral part of a trial burn. Direct addition of the POHC to the feed hopper worked extremely well for the NCBC trial burn whereas the attempt to mix the POHC with the sand in a cement mixer was unsuccessful. Future trial burn planners are discouraged from premixing the POHC with a solid matrix. Direct addition of the POHC to the feed system greatly simplifies POHC handling and input calculation.

f. Future trial burn planners are encouraged to employ persons with demonstrated successful experience with trial burns and to ensure that they are adequately supported by other technically competent personnel. Although this trial burn was successful, many errors were encountered that could have been avoided if the planning team were properly staffed and supported. The principal planners for this trial burn included three engineers working for the prime contractor and one technically degreed Air Force Project Officer whose primary responsibility was regulatory interaction and budget control. None of the planners had previously been involved in a RCRA trial burn. Additionally, very little engineering support was received from the incinerator subcontractor.

The development of the draft trial burn plan was conducted over a 7 day period. Following EPA review, the revisions to the plan were incorporated over a 21 day period.

Complex tests cannot be competently accomplished in such a short time period with such limited staff. Future trial burn planners are encouraged to at least double the staff and the time that was used for these tests.

g. Numerous problems were encountered during stack testing. Most of those problems were caused by high leak rates in the Method 5 and Modified Method 5 sample trains. A strong preventive maintenance program could have prevented some of the delays caused by the high leak rates. New glassware

with tightly fitting joints and routine inspection of all sampling components could have substantially reduced the leakage problems.

h. Although nothing can be done to control weather influences, action can be taken to reduce its effects. Test planners should consider the local weather and include an appropriate amount of time for weather delays in the test plans. Additionally, if shelters around the stack sampling ports can be constructed, then sampling may continue during adverse weather. During thunderstorms, however, safety precautions should preclude anyone from being on elevated steel platforms, which are typical of most stack sampling areas.

i. Based upon the analytical data from the NCBC trial burns, the MWP-2000 should be considered an acceptable technology for future hazardous waste remediation. This process is advantageous because it can process soil and other inorganic solids with little pretreatment. Additionally, it uses conventional and readily available equipment.

j. To ensure a successful trial burn, future test planners are encouraged to ensure that the incinerator operators and sampling team are well trained and have experience with the particular waste matrix or a suitable surrogate.

k. Test planners should ensure that all data acquisition instruments are calibrated and operable. Procedures should be in place to test and calibrate all critical equipment. The incinerator and complete DAS should be fully operable before the arrival of sampling contractors and at the beginning of the tests.

l. At least 1 week before the beginning of the test, the test planners should conduct a detailed operational readiness review meeting. That meeting should include competent and informed personnel from all disciplines involved in the test. During that meeting, all critical components and subsystems should be evaluated. If problems exist that would jeopardize the test, then a plan of action should be developed to solve the problem and test the component before the test.

m. Additionally, before each test day, a meeting should be conducted to ensure smooth coordination between the sampling team, the operations team, and project management. The site safety representative should be in attendance at those meetings.

n. Following each test, an informal meeting should be held to discuss any problems that developed during the test and how they were resolved. The attendees should discuss methods of how to avoid or solve the problem during subsequent tests.

C. INCINERATOR OPERATIONS

1. Discussion

Incinerator Operations (soil processing) started on November 25, 1987 and continued through November 19, 1988. During this time, over 26,000 tons (about 15,000 yd^3 of soil were processed. The processed soil (ash) was transferred from the incinerator to 20 yd^3 rolloff boxes where it was held pending analytical results. When the analytical results from each rolloff box confirmed that the 2,3,7,8-TCDD, total TCDD, and total TCDF were all less than 1.0 ppb, the processed soil was declared clean and transferred to a clean plot for storage. The date, plot number, and rolloff box number were recorded at the time of storage; this information was recorded in a computer data base for potential use during the delisting and site closure process.

Excess process water was discharged from the incinerator, through a sand filter to two 10,000-gallon storage tanks located outside the exclusion area fence. When one tank was at least three-fourths full, the water was circulated through a carbon bed and sampled. The sample was analyzed for pH, 2,3,7,8-TCDD, 2,4-D, and 2,4,5-T content. When the analytical results showed all analytes to be nondetectable and the pH to be not less than 5.5 nor greater than 9.5, the water was discharged to the POTW. A description of the Specific analytical methodologies can be found in Reference 10.

The demobilization task primarily consisted of dismantling the incinerator and loading it on trailers for shipment to the ENSCO facilities in

White Bluff, Tennessee and decontamination of all equipment used for the project.

All items were decontaminated using a high-pressure steam system. Swipe samples were taken on all decontaminated equipment and sent to a laboratory for analysis of 2,3,7,8-TCDD. Equipment was recleaned as necessary to meet a 40-nanogram/m^2 upper limit. Clean equipment was moved to a staging area outside of the exclusion area.

Smaller subtasks consisted of: (1) disposal of the trial burn sand, (2) disposition of the unused trial burn chemicals, (3) disposal of the used refractory brick from the kiln, (4) repair of the exclusion area fence, (5) repair of the railroad track, (6) removal of rental trailers that were used as office space, (7) disposition of excess equipment, and (8) a general cleanup of the area.

2. Incinerator Operations Conclusions

The purpose of the NCBC Demonstration Project was to demonstrate the availability and effectiveness of rotary kiln incineration for decontaminating soils containing constituents of Herbicide Orange. The remedial action and data collection efforts achieved the project goals.

While remediation had been performed on pilot- and small-scale efforts, it had not been performed on such a large quantity of soil before this project. This project revealed a number of technical, logistical, and regulatory issues that had not been necessary to address in the small-scale testing.

3. Incinerator Operations Recommendations

a. Strategic Planning

On a strategic planning level, the project should be planned chronologically from the end of the project back to the beginning. This enables project planning to focus on the final task goals.

Listed below for each of the project phases are some of the significant issues that future remedial action project planners should address.

- Demobilization
  Trip permits, hazardous materials disposal, dismantling of equipment

- Decontamination
  Location, equipment, materials

- Soil Handling
  Equipment, soil storage requirements

- Trial Burn
  Equipment, personnel, test apparatus, specific requirements

- Mobilization
  Trip permits, utility requirements, hand tools, spare parts, storage requirements, administration requirements, support requirements (cranes, set up personnel, etc.)

The consequences of the lack of planning focused on three primary areas: delisting, incinerator operations, and project costs (incinerator operations being the largest contributor to project cost). For future site remediation projects, the following guidelines should be followed:

b. Advanced Planning

1. Establish repair/replacement parts (fuel, oils, lubricant) inventory for all the equipment onsite at the onset of the project. Use an Economic Order Quantity model (or some variation thereof) to account for out of service time. Availability of repair parts should be known at all times.

2. Establish a checklist for shutdown planning. These checklists should be very inclusive and should consider all systems. Extra

needed equipment, materials services, and their scheduled availability date should be noted.

3. Review the subcontract requirements with the entire supervisory staff. The supervisory staff must know the reporting requirements, data collection requirements, allowable expenditures, permit violation consequences, etc.

4. Review the permit conditions with all site personnel. All personnel must be aware of the operating parameters to minimize the possibility of violations.

5. Establish a documented preventive maintenance system. A routine inspection and maintenance program will find many of the mechanical problems before failure. This could possibly avoid incinerator shutdown for unscheduled maintenance.

6. Much of the advanced planning should be performed before and during the permit application writing phase of the project. Numerous small details that are avoided by planning during the permit application will create untold delays and expense at a later date. For example, the original shredder used was inadequately sized for the cement-stabilized soil. A simple test using clean soil of equal matrix could have demonstrated the need for a larger shredder.

7. Avoid permit conditions that specify nondetectable (ND) analytical levels and establish reasonable upper concentration limits using well established analytical methodologies. Analytical interferences often make nondetectable limits impractical.

8. Establish the analytical requirements, including the protocols, detection levels, and method of handling outliers. Establish multiple analytical laboratories in order that their protocols may be identified and used. This should include the method for extraction of the samples. Establish requirements and methodology for interlaboratory variability studies and Practical Quantification Limits (PQL) for each of the

analytical laboratories. These methods should be approved by the regulatory agency.

9. Establish with the regulatory agency the requirement for the storage of the process ash.

10. Determine the broadest range of analysis requirements (protocols, level of detection, extraction method) that will be needed for each phase (trial burn, operations, delisting, and site closure) of the project.

11. Determine the reporting and data tracking requirements for all phases of the project. Establish clear and easy to use procedures detailing such information as, but not limited to, sample locations, sampling techniques, chain-of-custody, how data is to be reported, and how data is entered into the data base so that anyone looking at the data base can determine exactly which samples have been sent to the laboratory, which samples have been analyzed (and their results), and quite possibly which samples have been paid for. The objective of data management should be ease in retrievability.

12. Planning should also include the number and type of personnel needed to perform the tasks necessary to complete the project. As a minimum the subcontractor personnel should include:

a. secretary

b. bookkeeper

c. purchasing agent

d. spare parts controller

e. safety officer

f. operations manager

g. soil excavation crew

h. operations crew, including a supervisor for each shift, at least two control room operators on each shift and two soil handlers on each shift.

i. the customer or his representative should also be represented at the project site with a minimum of one person. If the incinerator operates continuously (24 hours/day, seven days/week) then two onsite project managers should be employed.

While these examples are not all inclusive, it does point out the need for a significant amount of advance planning.

D. INCINERATOR AVAILABILITY

1. Discussion

The goal of the incinerator availability evaluation was to determine the reliability of a mobile waste incinerator to incinerate HO contaminated soil. To accomplish that goal, data were collected from scheduled and unscheduled maintenance forms, daily reports, and the operators' and supervisors' logbooks.

Data associated with the initial system shakedown and testing period and the period at the end of the program when program-generated trash was burned were excluded. Only those data associated with the period from November 25, 1987 through November 19, 1988 were considered. During this period, a total of 26,058.4 tons of soil were processed.

The maintenance data base contained 1,223 records. These records comprised 358 scheduled maintenance events that accounted for 166 downtimes (auger off) (1,521.6 hours of component or system downtime), and 865 unscheduled maintenance events (899.1 hours of component or system downtime); a combined total of 2,421.7 hours or 100.9 days of components or system downtime. Not all events resulted in actual system shutdown. For example,

although the system auger may have been shutdown for a given event, this did not necessarily result in a system shutdown. If the incinerator had nearly a full charge of feed material at the time of the event, and feeding of material could again be started within approximately 20 minutes of the event, the system could continue soil processing. Thus for this evaluation, if a record did not explicitly indicate that the feed auger was not operating, it was assumed to be operating for those maintenance activities that involved 20 minutes or less time.

Of those components that required frequent maintenance, the shredder was the only component that exhibited a definite trend in the data. Maintenance was high in December 1987 (typical of a wear-in period), declined through the middle of the program (typical of a normal operating period), and then dramatically increased near the end of the program (typical of wear-out until a new, larger shredder was installed). This trend is called a "bathtub curve."

Seven of the 27 components considered in the evaluation required maintenance more than 50 times during the 12-month operating period. These components were: (1) weigh hopper, (2) shredder, (3) conveyor, (4) feed hopper, (5) kiln, (6) boiler, and (7) instrumentation. The Mean Time Between Failures (MTBF) of each of these components was less than 7 days. These component failures did not necessarily result in a system shutdown. The MTBF data show that the weigh hopper, shredder, kiln, and system instrumentation required the most frequent maintenance. The conveyor, feed hopper, and boiler also required frequent maintenance for problems such as plugging, binding, and fouling (e.g., particulate buildup on boiler face plate). However, the total number of maintenance events related to these components was less than half that of the total for the weigh hopper, shredder, kiln, and instrumentation. In comparison, the average time between failures for all 27 components was 0.7 days, with a standard deviation of 1.2 days and a range of 0 to 9 days.

A separate data base was maintained to record the cause and duration of automatic interlocks that activated the Automatic Waste Feed Shutoff System. The interlock data base contained 1,081 records. These records show that over the approximate 12-month period, a total of 14,461 interlock events

(automatic waste feed shut off) were reported. System downtime associated with these events amounted to 393.37 hours.

Auger instrumentation interlock events contributed significantly to the system downtime. These interlocks provided for operation of the system within prescribed operating limits through the monitoring of specified system parameters. The largest downtime was recorded during the months of December 1987 and April 1988. About 30% of the downtime in December was attributed to the Low Kiln Outlet Temperature (LKOT) interlock. In April, over 60% of the downtime was caused by the High Average Feed Rate (HAFR) interlock. The largest number of events occurred in December 1987 and February 1988. The LKOT and the Low Retention Time (LRT) interlocks accounted for over 60% of the events in December and the HAFR interlock accounted for more than half of the events in February.

By far, the largest contributor to downtime was the HAFR interlock, with an interlock occurring nearly every day. The number of interlocks per month began to decrease in March 1988. Although there was a decrease in the number of HAFR interlocks, an increase in the total downtime and the downtime per interlock resulted. See Table 5 for more specific information on monthly HAFR interlocks.

Scheduled maintenance events were more frequent early in the program, and less frequent starting in May 1988. Scheduled maintenance times started high, dropped, and then increased near the end of the program. Again, this trend resembles the bathtub curve. This may be attributable to system initial startup and wear phenomena; but maintenance time may be inversely proportional to the number of scheduled maintenance events. Based on the data available, the number of scheduled maintenance activities became less frequent as the program progressed. This is attributed to operational changes made such as slowing the kiln rotational rate and lowering the draft through the system to minimize the particulate carryover throughout the system.

TABLE 5. MONTHLY HAFR INTERLOCKS

Month	Downtime (min)	Number of interlocks	Average downtime (min)
11/87	0	0	-
12/87	80	449	0.18
1/88	157	540	0.29
2/88	607	1212	0.50
3/88	1114	296	3.76
4/88	2050	659	3.11
5/88	1376	411	3.35
6/88	752	183	4.11
7/88	669	139	4.81
8/88	650	152	4.28
9/88	1092	305	3.58
10/88	1890	539	3.51
11/88	384	76	5.05
Total	10,821	4,961	2.18

Scheduled maintenance accounted for 56.1% of the system downtime, unscheduled maintenance 29.1%, and interlocks 14.8%. The data show that the feed auger was shut down a total of 2,643.68 hours for all three of the system event types. The system was shut down an average of 7.3 h/day.

The total parts costs during the operation period of November 25, 1987 through November 19, 1988 amounted to $169,878. Nearly 70% of these costs were for the shredder and kiln. Most of these costs were incurred in March, July, and September. During March, the shredder teeth were changed, the kiln refractory was repaired, and kiln seals were replaced. During July, the shredder teeth, bearings, seals, lock nuts, end caps, and spacers were replaced. The largest parts cost of $60,000 (35% of total parts costs) was incurred in September for replacement of the shredder.

After the incinerator was shipped from Gulfport, Mississippi to the ENSCO facilities at White Bluff, Tennessee, the unit was thoroughly inspected. This inspection showed the only major items needing repair or replacement were the ash conveyor system and the rotary kiln seals. Additional parts were

needed for pumps, pump seals, and pump strainers. The cost for parts and materials for the repair made at White Bluff, Tennessee was $18,132, bringing the total cost for parts for the project to $188,010.

2. Incinerator Availability Conclusions

The overall availability of the incinerator was 68%. This is based on the total available hours for the 360 days of soil processing versus the total downtime for scheduled maintenance, unscheduled maintenance, and instrumentation interlocks of 2,648 hours or 110 days.

3. Incinerator Availability Recommendations

The following are items that contributed to the nonavailability of the incinerator. Most of these were corrected at some time during the project while others need corrective action for future projects.

a. Trunnion Rollers

The original trunnion rollers for the kiln were hollow with the bearing plates welded to them. Several of these rollers broke prompting a change to a solid roller. As each hollow roller broke, it was replaced with the new solid type. The solid rollers caused no problems for the duration of the program.

b. Shredder

During the project, a large volume of tyveks, wood, ground cloth, rocks, and other waste products that required incineration were generated. The shredder used for the first 9 months of the project was inadequate to shred this material for incineration. In the latter part of August, 1988, this shredder broke down. The time for repair was estimated to be approximately 2 weeks, as bearings had to be ordered from the factory. A decision was made at that time to purchase a used, larger shredder (Saturn Model No. 5232HT) in order to get the incinerator on line as quickly as possible. Table 6 lists the specifications for the 5232HT Shredder used for the NCBC Demonstration Project. A shredder with similar capabilities should

TABLE 6. SATURN 5232HT SHREDDER SPECIFICATIONS

No. of Motors	2
HP of Motors	75
Total Electric Motor HP	150
No. of Hydraulic Pumps	2
Hydraulic Pump Displacement (Cu In/Rev/Pump)	8.69
Total Flow to Hydraulic Motor (GPM)	135.40
Hydraulic Motor	MHR 525
Hydraulic Motor Displacement (Cu In/Rev)	523.90
Hydraulic Motor Shaft Speed (RPM)	59.70
Hydraulic Motor Torque (Ft-#'s)	15,941
Shaft Torque (Ft-#'s)	
Slow Shaft	46,771
Fast Shaft	33,875
Gear Ratio	
Slow Shaft	2.934:1
Fast Shaft	2.125:1
Shaft Speed (RPM)	
Slow Shaft	20.30
Fast Shaft	28.10
Cutter Diameter (inches)	15.75
Tooth Force (lbs)	71,270

be used for future remediation projects. This new shredder also eliminated the need for a wood chipper to cut up approximately 600 railroad ties being used by the project for loading and unloading ramps. The shredder was received and installed within a few days, solving many problems including the avoidance of lost incineration time.

c. Kiln Seals

The first set of seals (front and back) for the kiln wore out within a few months. When a new set of seals was installed in March, it was suggested a lubricant be used to ease the friction during the constant

rotation of the kiln. Using Molylub® periodically allowed the seals to last through the remainder of the project.

d. Weigh Hopper/Feed System

A necessary design change for the next project would be to separate the weighing system from the shredder. The current system has the weigh hopper first and then the shredder; whereas, a better system would be to place the shredder first and then a weighing system completely separate from the shredder. This would eliminate the fluctuations in recorded weights on the computer monitoring system as the shredder bounced while shredding rocks and wood. This was especially noticeable during September after the installation of the new shredder. On a couple of days, the computer saw weight changes in the weigh hopper equal to 100 tons, when the actual tonnage processed was in the 60-ton range according to the weigh hopper log sheets. Under the same conditions as this project, a conveyor weigh system would probably work better.

e. Water Jacket on Auger Chute

While this is not a major item, the water jacket had potential to be a source of ash contamination. The water jacket is designed to keep the auger and auger chute cool during processing of high British Thermal Unit (BTU) combustible materials; however, the moisture in the soil processed was enough to keep the auger and auger chute at a cool operating temperature. The water jacket was used until it developed a leak allowing the water to come in contact with the contaminated soil. This jeopardized the processed soil (ash), as the potentially contaminated water from the water jacket was used for the ash conveyor makeup water. Rather than repairing the water jacket, a solid chute was fabricated as a replacement. The incinerator was shut down to locate the water jacket leak, contributing to the unscheduled maintenance time.

f. Auger Shear Bolt

As the first feed auger wore down, it started to wobble inside the auger chute. This wobbling caused the auger shear bolt holes to become elongated (out of round). Although a new auger was installed, the wobbling effect could still take place because of the space around the shear bolt holes. This wobbling caused the shear bolts to snap, which in turn meant an hour or two of downtime to dig the soil out of the feed hopper to replace the bolts. A change in design placing the shear bolts on the auger shaft outside of the feed hopper was made, expediting this procedure.

g. Overlay on Auger Flights

The feed augers used on this project were fabricated from stainless steel. The first auger processed 3,325 tons of soil before wearing the flights down to the point that the auger wobbled in the auger chute causing the shear bolts to break. To minimize the feed auger wear, a 2-inch tungsten carbide cap was plated onto the flights of the replacement auger. The auger with overlay processed 11,429 tons of soil before being replaced with a similar type. Measurements showed the auger flights had worn approximately 1/2 inch.

h. Setting Process Equipment on Contaminated Plots

During the initial setup of the incinerator in the fall of 1986, the weigh hopper/conveyor system was set on plots already characterized as being contaminated. As the project neared completion, it became necessary to move the weigh hopper/conveyor system to complete soil excavation. The unit downtime to complete this change was approximately four days, at a cost of approximately $100,000 (based on an estimated cost of $25,000 per day). Better planning during the initial setup would have possibly eliminated this costly downtime. For the NCBC Demonstration Project it appears that setting equipment on contaminated plots was unavoidable. Regardless of the original positioning of the equipment, it would have to be moved to complete soil excavation.

i. Using Gunnite® as Replacement For Refractory Brick

In early March 1988, several refractory bricks fell out of the rotary kiln, prompting a unit shutdown to make the necessary repairs. Rather than replacing the lost brick with new brick, a decision, based on the vendor's evaluation, was made to patch the area with Gunnite® (a grout type material). The Gunnite® patch lasted less than two weeks, at which time the unit was shut down again to make repairs. The second repair was made using refractory brick.

It is very probable that the Gunnite® material would hold up under normal operating conditions; however, the abrasive materials that were being processed at NCBC probably contributed to the early wear-out of the Gunnite®.

j. Particulate Carryover

Particulate carryover from the kiln into the SCC, packed tower, and boiler was the major contributor to scheduled maintenance downtime. Scheduled outages were always based on the quantity of particulate in the SCC, usually 20-25% of SCC capacity. In the early stages of soil processing, those outages occurred approximately every 30 days. Particulate carryover was reduced dramatically, starting in March, by slowing the rotation of the kiln, and lowering the draft through the systems. Those actions reduced the source of particulate (fluffing of soil in the kiln) and by decreasing the air velocity through the system, the ability of the airborne particulate to carryover to the boiler was also reduced. This resulted in a scheduled outage for maintenance occurring every 59 days for the remainder of the project. The particulate was cleaned from the SCC, boiler, and packed tower every scheduled outage. In addition, approximately every 7 to 10 days the system was shut down for 30 minutes to 4 hours to clean the boiler tubes or scrape the boiler face plate. These outages were usually classified as unscheduled maintenance. The operating changes mentioned above were made to minimize the inadequacy of the cyclone separators. To fully resolve the particulate carryover problem, a change should be made in the design of the cyclones.

k. Preventive Maintenance

The lack of a preventive maintenance program was another major contributor to system nonavailability. In this case, it was usually in the form of unscheduled maintenance. The lack of a preventive maintenance program resulted in either finding mechanical problems during scheduled outages or the component or subsystem failing during operations. Depending on the component or subsystem, a failure during operations often resulted in a shut down of the incinerator.

E. SOIL EXCAVATION

1. Discussion

Excavation entailed not only the plot soil excavation but also bottom- of-hole (BOH) sampling and ambient air monitoring. During the course of the project, over one thousand 20- by 20-foot plots were excavated from 3 inches up to as much as 51 inches deep. The original RD&D permit was based on excavating 11,000 yd^3 of contaminated soil. The RD&D permit was revised twice. The first revision to the RD&D permit allowed up to a total of 14,000 yd^3 of soil to be excavated, while the second RD&D permit revision allowed up to a total of 15,500 yd^3. Total soil excavated, based on an average density of 1.75 tons/yd^3 was approximately 14,900 yd^3.

The soil excavation was accomplished using a variety of equipment that included a bulldozer, dump truck, front-end loader, asphalt mill (planer), and, at times a track hoe (excavator). In Areas A and B (see Figure 1), the bulldozer was used to remove the layer of soil over the concrete stabilizer. The planer was then used to cut the concrete-stabilized soil. The soil/concrete was scooped up by the front-end loader and placed in the dump truck for transport to the soil storage area. After the initial excavation of a plot, the concrete-stabilized layer was usually too thin to use the planer a second time, so either the bulldozer or track hoe was used to re-excavate those plots if necessary.

In Area C, the soil was not concrete-stabilized, therefore the planer was not needed. All plots in Area C were excavated using only the track hoe and dump truck.

2. Soil Excavation Conclusions

Soil excavation began on November 25, 1987 and continued through November 11, 1988. During that time, 1,006 20-ft by 20-ft plots were excavated. These were broken down as follows:

Area A = 757
Area B = 216
Area C = 33

Numerous plots in the three areas had to be excavated more than once. Table 7 shows a breakdown of these re-excavations by area.

TABLE 7. NUMBER OF PLOTS VS. NUMBER OF EXCAVATIONS

Plot	Number of Times Excavated							
Area	1	2	3	4	5	6	7	Total
A	497	178	47	23	8	2	2	757
B	184	21	6	4	1	0	0	216
C	18	9	2	2	1	1	0	33
Total	699	208	55	29	10	3	2	1006

3. Soil Excavation Recommendations

The following items are recommended changes for a project similar to the NCBC Demonstration Project.

a. Ash and Soil Sampling

Designate one person to be in charge of all sampling and keep the records. Have several laboratories on contract to analyze samples because one laboratory might be overloaded or have equipment and/or labor problems.

Have a second person involved in the sampling paperwork that is ready to take over if the person in charge is sick or otherwise unavailable.

b. Soil Storage

A large covered soil storage area is a necessity for drying and maintaining the necessary stockpile of contaminated soil for weekend operation and operation through the times that excavation is not possible. Equipment breakdown and weather are the major factors contributing to excavation down time.

Based on NCBC Demonstration Project experience, it is advisable to have a soil storage area large enough to store at least a seven day supply of contaminated soil. Obviously, an incinerator operating in a dryer climate would not require as large a stockpile of contaminated soil.

c. Excavation Equipment

Most of the equipment required for soil excavation and handling was rented. The use of rented equipment is justified for short duration projects. If excavation or operation of equipment is long term (6 months or greater), then a lease with option to buy or purchase of equipment is more economical. Originally, the NCBC Demonstration Project was not predicted to last longer than six months, thus most of the equipment was rented.

The duration of a project must be realistically projected and the necessary equipment rented or purchased based on that projection. If a project duration cannot be predicted with a high degree of certainty, rent or lease contracts with options to purchase are recommended.

d. Excavation Techniques and Soil Processing

The planer was limited to excavating the cement-stabilized soil to a maximum depth of 6 inches. The planer produced a very homogeneous soil that fed through the weigh hopper and shredder without difficulty. Soil excavation by other equipment contained cement-stabilized chunks, rocks, metal rods, shredder or conveyor belt. This caused incinerator processing delays

while a worker would have to climb in the weigh hopper to remove the debris. These delays could be minimized by separating the shredder from the weigh hopper. The shredder should be a separate preprocessing step that all soil (except planer excavated soil) should go through prior to weighing and feeding to the incinerator.

The planer used at NCBC was not equipped with a proper attachment for excavating soil; it was designed to operate on hard surfaced roads. It is recommended that the planer be equipped with large lugged wheels or tracks to make it maneuverable on soft ground and to provide the traction to pull itself out of areas excavated to a depth of 1 to 2 feet. The planer should also be equipped with a conveyor belt that would convey the excavated soil into a trailing dump truck.

e. Ash Storage

The ash from the incinerator was stored in metal rolloff boxes until laboratory analysis results confirmed it was clean (less than 1.0 ppb of 2,3,7,8-TCDD, total TCDD, and total TCDF). The ash was then removed from the rolloff boxes and off-loaded onto a specified area of the excavation site. Storage and containment of the ash is critical until the ash sample results are known. For proper containment, nonleaking, covered, ash storage boxes are required. When contracting for the ash storage boxes, the project engineer must specify their leak tightness and they should be leak tested prior to acceptance and use. The placement of incinerator ash on the excavation site may not be feasible or desirable. The ash may be stored on another site while waiting for delisting approval. If the ash is not delistable, it will be necessary to transfer it to a regulated landfill. Ash delisting requirements must be negotiated with the regulating agencies prior to the start of incinerator operations. Although, this option was not possible for the NCBC Demonstration Project, recent changes in the regulations have made "up front" delisting possible.

f. Decontamination Pad

The final decontamination pad at NCBC was made with a carbon steel base and a plastic tent top. At the end of the decontamination task,

the potentially contaminated plastic was burned in the incinerator and the carbon steel base cleaned using steam and high pressure water. The decontamination water was also processed through the kiln. A previous decontamination pad was constructed with a concrete base that would have been very difficult to decontaminate if the contamination had penetrated the concrete surface. Decontamination pads should be built of combustible materials and/or materials with nonporous surfaces that can be decontaminated easily. Another concrete pad on the site that was used for handling bulk quantities of neat HO, had to be jackhammered to remove a one inch deep layer of concrete before it was decontaminated. Although that pad observed extremely high levels of HO and TCDD, it serves as an example of how certain organics can penetrate concrete.

g. Ambient Air Monitoring

It is recommended to use local personnel to perform air monitoring. These personnel must be available at all times due to the changing excavation schedules. It is also recommended to have, as a minimum, two spare electric generators and two spare samplers in good working condition onsite to replace those that breakdown during soil excavation activities. In addition, a regular scheduled maintenance program based on the manufacturers recommendations should be employed.

F. PROJECT MANAGEMENT/SITE SERVICES

1. Discussion

Site services for the project focused on the services necessary for the operations and excavation personnel to properly perform their assignments. These services included radio communications, telephone services, and secretarial services. In addition, parts, material, and fuel were supplied to operate the incinerator and auxiliary equipment. Program Management was basically support from EG&G Idaho.

Project Management costs for the early periods during incinerator set up and the trial burn are not easily defined. Numerous miscellaneous costs were added to the project management costs that are now impossible to

separate. From May 18, 1987 through the end of the project, the Project Management task was separated into three subtasks: Project Administration, Technical Management, and Miscellaneous Support & Materials. Costs for the Holding Period May 18, 1987 through August 30, 1987 were: Project Administrations, $18,839; Technical Management, $16,411; and Miscellaneous Support & Materials, $0. For the Decontamination/Demobilization period, December 1, 1988 through February 19, 1989 the costs were: Project Administration, $7,824; Technical Management, $40,441; and Miscellaneous Support & Materials, $3,907.

Total costs for project management from May 18, 1987 through February 19, 1989 were: Project Administration, $193,255; Technical Management, $271,625; and Miscellaneous Support & Materials, $55,980.

Site Services costs during the Decontamination/Demobilization phase of the project totaled some $29,600. Site Services costs for the soil processing period November 25, 1987 through November 19, 1988 were approximately $157,535. See Figure A-7 for a detailed breakdown of Site Services costs for the period May 1987 through February 1989.

2. Project Management/Site Services Recommendations

a. Data Management

Different data transmission systems were used for various types of data, depending on the turnaround time required for each particular data set. One of the most efficient methods was to use telecommunications software via computer modem to transmit the data to the EG&G Idaho office. In cases where personnel were not available to process the transmission, the data was copied to a computer disk and express mailed to the EG&G Idaho office.

When transmitting hard copy data, it was important to first determine the turnaround time needed for this data. If immediate receipt of the data were needed by the main office, then the telefax machine was used. If there was no immediate need for the data, it was transmitted by express mail service. Most information was transmitted by the express mail service,

although occasionally information was required to answer questions and was, therefore, telefaxed.

The data from the BOH soil samples were analyzed to make several determinations during the course of the project.

Examples of these determinations included the following:

1. Predicting the quantity of soil remaining to be excavated/processed

2. The depth of cut to make during excavations, and

3. The composite makeup for obtaining total dioxin and total furan chemical analysis.

As analytical results were received from the laboratories, copies were made of the telefaxed data sheets with one copy being placed in the daily files and a second copy transmitted to the EG&G Idaho Project Office in Idaho Falls, Idaho. Copies of the data base were also made each day on computer disks and placed in one of the fireproof files.

Although all sample data were entered into the data base at the NCBC project office, the official data base files were kept at the INEL. All data base information were transmitted from the NCBC to the INEL via a computer modem telecommunication system. At the INEL, the information contained in the data base was validated by the EG&G Idaho Data Manager as part of quality control by comparing 10% of the entries against the hard copy (chain of custody) received from the laboratory. Any discrepancies were corrected on the official data base at the INEL and then transmitted back to the NCBC project office via the computer modem.

The data base information was also spot checked periodically during the project by the EG&G Idaho Program Coordinator and given a thorough review by the Program Coordinator and Data Manager at the completion of the project.

Some discussion was presented here on the data management methods used at NCBC, but this is not necessarily the recommended system. A more economical, and certainly more efficient system is to maintain only one set of data and have that at the project site. This would eliminate the daily expense of telefaxing the analytical data to the home office and then express mailing copies of the same data. It could, quite possible, also eliminate the need for a separate data entry clerk, as the Data Manager could enter the data.

When the data base information was eded at the home office, a copy of the data base could be printed and mailed. If a more expedient response is desired, the option to transmit the data base via the computer modem was still available.

A second recommendation for future projects would be to use a bar coding system for data collection. The process is simple and eliminates several potential areas for errors. A bar coding system can be setup and operated at a minimal cost.

Bar coding is an excellent environmental tracking tool in that using a "check digit" at the end of the bar code ensures accuracy to one error in a million. Compared to the one error in 38 that is generally figured for the average data input clerk, this is a significant increase in accuracy.

The process would be used to its maximum efficiency by starting the process out in the field with the sampler printing and attaching the appropriate sample label off of their portable, belt-attachment bar code printer. The sample jars would then be scanned by the personnel preparing them for shipping, with this information being easily uploaded to a data base on a standard PC system. A chain-of-custody form could then be automatically and accurately printed from the data in the data base. Most of the laboratories currently use bar coding and the DOD has standardized a symbology for printing the bar codes.

Bar coding eliminates the need for a data entry clerk and it also enables the sampler to be able to clearly and accurately label the sample jar

in the field, thus cutting down on further chances for bottle and label mix up and the possibility of the sampler transposing information.

The cost of bar coding equipment, labels, software, etc. is generally reasonable and could pay for itself quite rapidly, depending upon the application. Many brands of bar coding equipment are built to handle the harshest of environments for data collection and input.

b. Clerical

The office management duties were the prime responsibility of the ENSCO secretary. These duties included answering the telephone, sending and receiving telefax information, coordinating visitor and vendor clearance through the NCBC security gates, and ordering the daily office supplies. The office management activities played a major role in maintaining a reasonably smooth operation. In addition to the secretary, there was also a data entry clerk for entering daily sample data into the data base and maintaining the daily files.

The data entry clerk and bookkeeper on the NCBC Demonstration Project were hired from local job shop services. It is recommended that these personnel be permanent employees from the subcontractor's parent organization so that they would be familiar with company procedures.

c. Security

During off-hours, the main office and bookkeeper's areas were kept locked. The only personnel authorized in those areas during the off-hours were the EG&G Idaho site representatives, ENSCO Plant Superintendent, Secretary, and Bookkeeper. In addition, ENSCO kept their personnel file locked at all times and EG&G Idaho personnel kept the daily files locked.

A further measure of security were the manned entrance gates to the NCBC. Normal security personnel checked all personnel entering the base on a 24 h/day basis. All visitors to the project had to be cleared through the NCBC security gates.

d. Communications

There were two types of communicating services that played important roles during the project.

1. Telephone

The main telephone service in the office area was through a distribution box called Eagle One®. Twice during the project the power supply failed leaving the office area with one telephone and that was the telefax line. Another important factor was finding a company to service the system. Both times the system failed, it required several days to find a service representative. Because of the problems with power supply failures, and most importantly, finding a company to service the equipment, it is recommended that the project use AT&T or equivalent, for all telephone services.

2. Radio

Portable VHS radios were used by both the operations and soil excavation personnel. During the verification and trial burn tests there was a conflict of frequency with the Gulfport Dock facilities. The radios had to have new crystals installed to change the frequency and eliminate this problem. During the verification and trial burn tests one of the subcontractors used CB radios. While this worked, the noise and chatter were often hard to overcome.

It would be best to start off a project with a good set of portable and desk mounted VHS radios with a project exclusive channel (frequency). This channel would be permitted and assigned the Federal Communications Center (FCC). Portable VHS radios typically cost approximately $1000 each.

e. Plan of the Day Meetings

The plan of the day meetings were initiated by EG&G Idaho during the trial burn. Air Force, EG&G Idaho, and ENSCO personnel would meet

to discuss what had been accomplished for that day and the plans for the next day. Although the overall plan for the project called for continuation of these meetings on a daily basis, this never materialized. With the heavy schedule of the day's activities, personnel changes, and finally the incinerator operations becoming fairly routine, the plan of the day meetings became less frequent until they became nonexistent.

f. Documented Plan of the Day

In November 1987, a Plan of the Day form was initiated to coordinate the daily activities of the project. The form, generated by an EG&G Idaho onsite representative, usually covered such items as soil processing, plot excavation and backfilling, sampling, and special activities. Copies of the plan were distributed each day to the Air Force, ENSCO Plant Superintendent, ENSCO Safety Officer, Versar, and the Excavation/Backfill crew. The original was kept on file by the EG&G Idaho site representative. The use of the Plan of the Day form was discontinued the first part of January 1989 during the demobilization of the incinerator unit.

g. Data Review Forms

A few weeks after the start of soil processing, a decision was made to create two forms for keeping track of the incoming daily data. One form would cover air monitoring and sampling and the other form would cover the operations activities. Each form was broken into categories to cover the type of data normally received. As the daily operational data were received, an EG&G Idaho site representative would review the data for completeness, date, and sign off in the appropriate space for each item received. To aid in the collection of the data on a daily basis, the operations form was revised to include spaces for ENSCO to initial to show that they had collected the data and transferred them to an EG&G Idaho site representative. Normally, an EG&G Idaho site representative filed the operational data in the appropriate file after reviewing the data. The sampling data were normally received by an EG&G Idaho site representative directly, who would review the data sheets for completeness, initial, and date them. These data were then given to the data clerk, who would enter the data on the data base and then file the data sheets.

h. Action Item List

Because of the numerous activities taking place in preparing for the start of soil processing, an Action Item system was initiated on October 22, 1987. With this system, an EG&G Idaho site representative filled out an NCBC Action Item form, discussed the action item with the subcontractor superintendent or his alternate, and issued copies to the subcontractor and the INEL. The original form was kept in an Action Item Logbook. As the action items were completed by the subcontractor, an EG&G Idaho site representative recorded the completion date in the logbook and on the original action item form.

In the latter part of March 1988, the action item list was extended to include action items between the Air Force and EG&G Idaho. This was done because numerous actions previously agreed to had been sidetracked or forgotten for a variety of reasons. These action items, normally issued by EG&G Idaho INEL personnel, were kept in a separate Action Item Logbook from the EG&G Idaho/subcontractor action items. The distribution for these action items was the Project, INEL, and Tyndall Air Force Base.

i. Review Meetings

During soil processing, there was only one formal project status meeting. That meeting was held at Tyndall Air Force Base on August 27 and 28, 1988. Participants in the meeting were the Air Force and EG&G Idaho. Informal meetings were held quite frequently when Air Force personnel were at NCBC. The informal meetings usually involved Air Force, EG&G Idaho, and ENSCO personnel and occasionally Versar personnel. No minutes were kept at these informal meetings.

j. Readiness Review Meetings

There were two formal readiness review meetings before the start of soil processing. The first meeting was held on September 3, 1987 and the second meeting on November 24, 1987. The first meeting was held anticipating a soil processing start of September 11, 1987, but because of

some last minute changes in the EPA permit, the scheduled startup did not occur on this date.

Upon completion of final negotiations with the EPA, the second readiness review meeting was held the day before soil processing actually started.

There were also two readiness review meetings before the end of soil processing and before the start of the decontamination and demobilization effort.

The first meeting was held at NCBC on September 15, 1988 with participants from the Air Force, EG&G Idaho, ENSCO, and Versar. This meeting was conducted to identify the major items affecting the completion of soil processing, the decontamination of equipment, and the demobilization of the incinerator unit. A hand-drawn schedule of the activities was presented by EG&G Idaho for review at this meeting.

A second readiness review meeting was held at NCBC on October 26, 1988 to finalize the activity schedule before formal submittal and to note any last minute major items that could affect the schedule.

k. Computer-Aided Scheduling

The decontamination and demobilization part of the project was planned and scheduled on computer program PROMIS®. The schedule for the decontamination and demobilization of the incinerator project was continually updated.

l. Audits

The control of the incinerator operations was maintained by onsite EG&G Idaho personnel who observed and audited the daily operations. The daily documentation for the incinerator, excavation, sampling, and air monitoring was reviewed for accuracy and completeness by EG&G Idaho onsite personnel. Any deficiencies observed were resolved routinely with the site personnel on a daily basis. If a permit or procedure noncompliance arose, the

appropriate action was taken. EG&G Idaho, Air Force, and EPA personnel were advised of any permit noncompliances on a timely basis.

The health and safety records and procedures used on the project were reviewed and audited by EG&G Idaho Health and Safety during the project. These audits supported the ENSCO Health and Safety Officer's efforts and resulted in safer procedures and work habits for the project. Any procedure and record deficiencies were identified at an early date and corrected by the subcontractor. The audits were conducted before major work efforts such as the decontamination and demobilization of the incinerator and during normal incinerator operation at the beginning of the project.

m. Reports

There were three reports issued to the Air Force by EG&G Idaho personnel, two of them from the onsite personnel and the other from the INEL.

1. The first of those reports was the daily report, which described the soil processing and excavation activities for the previous 24 hours. This report was telefaxed to Tyndall AFB on a daily basis (except weekends).

2. The second report was the weekly report. This report essentially contained the same information as the daily report except that it gave the weekly totals for tons of soil processed, hours operated, incinerator availability (expressed as %), and the number of plots excavated. There was also a comment section to explain downtime or other vital information. The weekly report was mailed to Tyndall AFB at the end of each week.

3. The third report was the monthly status report for the project and was transmitted to Tyndall Air Force Base from the INEL. The monthly status report contained the subproject summary, (a breakdown of the project into subprojects for ease of reporting) the funding and expenditure summary, open items/problem areas, and an action item statement.

n. Contract Administration

Subcontract Administrators played a key role in the management of contracts. Their participation in the project started at project inception by reviewing the scope of work and cost estimates.Other functions performed by the subcontract administrators included the following: (1) to formulate a bid list, if necessary, (2) place ads in the Commerce Business Daily, (3) issue the Requests For Proposal (RFP), (4) chair the selection committee that evaluated the submitted proposals, and (5) act as liaison between the contract requestor and proposer. Once the contract was let, their function was to administer the contract. In this capacity, they reviewed payments, monitored progress, negotiated contract additions and/or deletions, and helped resolve contract performance problems.

o. Records Management

Upon completion of the soil processing at NCBC, all of the daily records that had been on file in the fireproof files at the site office were repackaged into file boxes and shipped to the EG&G Idaho main office at the INEL. At the INEL, these files were assigned file numbers, cataloged, and the cataloged information entered on a computer data base. In addition to the daily records from the project site, all of the project data generated at the INEL from the management side and/or the chemical analysis evaluation side were handled similarly. The documents from this project will be stored per EPA regulations for records detention.

In retrospect, it would have been beneficial to a project of this magnitude to set up the project file numbers and cataloging before the start of the project. It is much more time consuming to initiate this process at the end of the project. Another reason for initiating a document management system at the beginning of a project is to make a determination on whether to microfilm all documents to save space. It would be extremely expensive to make that decision after all the documents have been generated.

p. Sample Turnaround Time

All samples were shipped from the site via Federal Express. The Federal Express pickups were normally made in the late afternoon with a next day delivery to the respective laboratory except for those shipments made on Friday. A Saturday delivery to the laboratory was not requested on a routine basis.

Normally, one-third of the BOH soil samples shipped each day were on a three-day turnaround, which meant that after receipt of the samples by the laboratory we could expect results within three days. The remaining two-thirds of the soil samples shipped on a particular day were to be analyzed within five days after receipt at the laboratory. Ash samples and soil composite samples were routinely analyzed on a five-day turnaround after receipt at the laboratory. The BOH soil samples were on a quicker turnaround schedule than the ash sample because of the need to know what plots were to be excavated or re-excavated.

The analytical results were recorded on the chain of custody form accompanying the samples and telefaxed directly to the project office at NCBC. A formal report of the analytical results was issued directly to EG&G Idaho by the individual laboratories at a later date.

SECTION V
COST ANALYSIS

The costs for the NCBC Demonstration Project were arbitrarily broken down into the following nine categories, listed alphabetically:

1. Air Monitoring
2. Ash Storage
3. Common Events
4. Decontamination/Demobilization
5. Excavation
6. Incinerator Operations
7. Office/Site Services
8. Rock Crusher
9. Soil Storage

The costs were collected for May 1987 through February 1989 (22 months). See Table 8 for other substantial costs not listed above that a monthly breakdown was not available for.

The costs for analytical services are included under their respective category (e.g., swipe samples analysis costs are included in the D&D category, BOH sample analysis are included in the excavation category, etc.).

The nine category titles are self-explanatory as to what they contain except, possibly, for Common Events. The Common Events category includes the following items: (1) Federal Express, (2) United Parcel Service (UPS), (3) fuel tanks, (4) break trailer, (5) radios, (6) miscellaneous equipment, and (7) telephone.

Tables A1 through A9 in appendix A are the individual spread sheets for the nine categories showing the monthly expenditures listed by category item. The careful reviewer will notice that some of the spread sheets do not contain certain time periods. In such cases, no costs were incurred and therefore are

TABLE 8. COSTS[a] FOR SEPTEMBER 1986 THROUGH APRIL 1987

Mobilization	
Preparation of Incinerator for Shipment	$ 12,675
Incinerator Transport	25,853
Site Preparation	113,599
Incinerator Setup	330,023
Shakedown/Verification Test Burn	217,580
Operations	56,201
Site Services	128,301
Holding Periods (mid December 1986 through April 1987)	462,599
Total 9/86 through 4/87	$1,346,921

a. Costs supplied by ENSCO

not reported in the spread sheet. This same information is shown in graphic form in Figures B-1 through B-9, Appendix B. The wide variation in air monitoring costs, as shown in Figure B-1, were due to the number of Versar personnel required to perform this activity, the air sample analytical costs, and the required air sample techniques. During the initial stages of soil excavation (October 1987 through February 1988), the samplers were operated for longer periods of time requiring around the clock coverage. In March 1988 a change was made to the air monitoring procedure allowing a reduction in onsite Versar personnel and number of sampling stations.

The decontamination/demobilization task was in the initial stage at the end of November 1988. By calculating the cost/ton using the soil processing period, it minimizes the decontamination/demobilization costs because only a portion of the decontamination/demobilization costs are factored in. The cost/ton is $230/ton when the total decontamination/demobilization costs are taken into account.

The individual category expenditures and their associated cost/ton for the two time periods can be found in Tables 9 and 10.

TABLE 9. CATEGORY EXPENDITURES AND COST PER TON FOR MAY 1987 THROUGH FEBRUARY 1989

Category	Expenditure ($)	$/Ton[a]
Air Monitoring[b]	$ 489,467.06	$ 18.78
Ash Storage[b]	384,150.75	14.74
Common Events	94,153.40	3.61
Decontamination/Demobilization[b]	464,349.56	17.82
Excavation[b]	1,537,992.92	59.02
Incinerator Operations	4,367,409.28	167.60
Office/Site Services	240,356.05	9.22
Rock Crusher	15,060.14	0.58
Soil Storage	10,944.56	0.42
TOTAL	$ 7,603,883.72	$ 291.80

a. Based on 26,058.4 tons of soil processed.

b. The total costs for analytical services for the project were $1,597,646 or $61/ton of soil processed. These costs are included in the categories listed above.

Table 11 is a cost breakdown by month, for the time period May 1987 through February 1989. The trial burn occurred in May 1987 resulting in expenditures of $200K followed by a hold period negotiated between EG&G Idaho and ENSCO at $100K/month for the next three months. With the anticipated imminent approval of the EPA permit in September, costs rose substantially. This remobilization phase lasted through October and into November before the permit was finally approved in late November. Although soil processing started in late November 1987, these costs do not show up until December 1987. As can be noted, the costs doubled in December 1987 from their November 1987 level to $500K mainly because of the materials cost. Costs remained fairly

TABLE 10. CATEGORY EXPENDITURES AND COST PER TON FOR DECEMBER 1987 THROUGH NOVEMBER 1988

Category	Expenditure ($)	$/Ton[a]
Air Monitoring	$ 343,304.04	$ 13.17
Ash Storage	342,560.58	13.14
Common Events	72,276.54	2.77
Decontamination/Demobilization	91,885.28	3.53
Excavation	1,462,014.10	56.10
Incinerator Operations	3,101,801.04	119.03
Office/Site Services	169,909.32	6.52
Rock Crusher	15,060.06	0.58
Soil Storage	10,944.56	0.42
TOTAL	$ 5,609,756.12	$ 215.28

a. Based on 26,058.4 tons of soil processed.

consistent at $400K/month to over $500K/month during soil processing. This is shown in the subtask spread sheets (Tables A-1 though A-9). The project monthly costs are graphically displayed in Figure 22. Figure 23 is a chart showing the distribution of the project costs per subtask. Not included in these project costs are Project Management costs.

Table 12 shows the total project costs and cost/ton of soil processed for the time period September 1986 (when the incinerator arrived at the NCBC site) through February 1989 (completion of the on-site activities), including the two hold periods (mid December 1986 through April 1987 and mid May 1987 through August 1987). Also shown in Table 12 are the total costs and cost/ton without the two hold periods.

TABLE 11. MONTHLY PROJECT COSTS

May 1987	$ 204,489.24
June	106,895.15
July	110,291.90
August	94,961.12
September	176,838.85
October	256,030.80
November	259,956.39
December	502,477.57
January 1988	478,615.77
February	552,152.42
March	466,943.39
April	413,898.55
May	471,755.66
June	422,570.60
July	444,325.67
August	444,572.19
September	467,594.69
October	535,368.93
November	424,100.68
December	321,049.07
January 1989	245,826.48
February	203,049.07
Total	$7,603,853.72

TABLE 12. TOTAL PROJECT COSTS FOR SEPTEMBER 1986 THROUGH FEBRUARY 1989

Category	Costs ($)
Mobilization	$ 38,528
Site Preparation	113,599
Incinerator Setup	330,023
Shakedown/Verification Test Burn	217,580
Operations	56,201
Site Services	128,301
Holding Period (mid 12/86 through 4/87)	462,599
Trial Burn	204,489
Holding Period (6/87 through 8/87)	312,148
Preparation for Soil Processing	692,826
Soil Processing	5,517,871
Decontamination/Demobilization	464,349
Project Management (EG&G Idaho)	934,801
Total Costs	$ 9,473,315
Cost/ton based on 26,058 tons of soil processed	$ 363
Costs without holding periods	$ 8,698,568
Cost/ton without holding periods	$ 334

The NCBC Demonstration Project total unit costs for the soil processing period of December 1987 through November 1988 (including EG&G Idaho Management costs) were approximately $220/ton for the 26,000 + tons of soil processed. Included in the cost/ton, but not the tonnage, are costs to incinerate process generated wastes such as coveralls, hoods, gloves, and rubber boots.

The costs from the time of the trial burns in May 1987, through the demobilization in February 1989 were approximately $292/ton. This included the hold period of May 16, 1987 through August 1987 when no onsite activities were taking place.

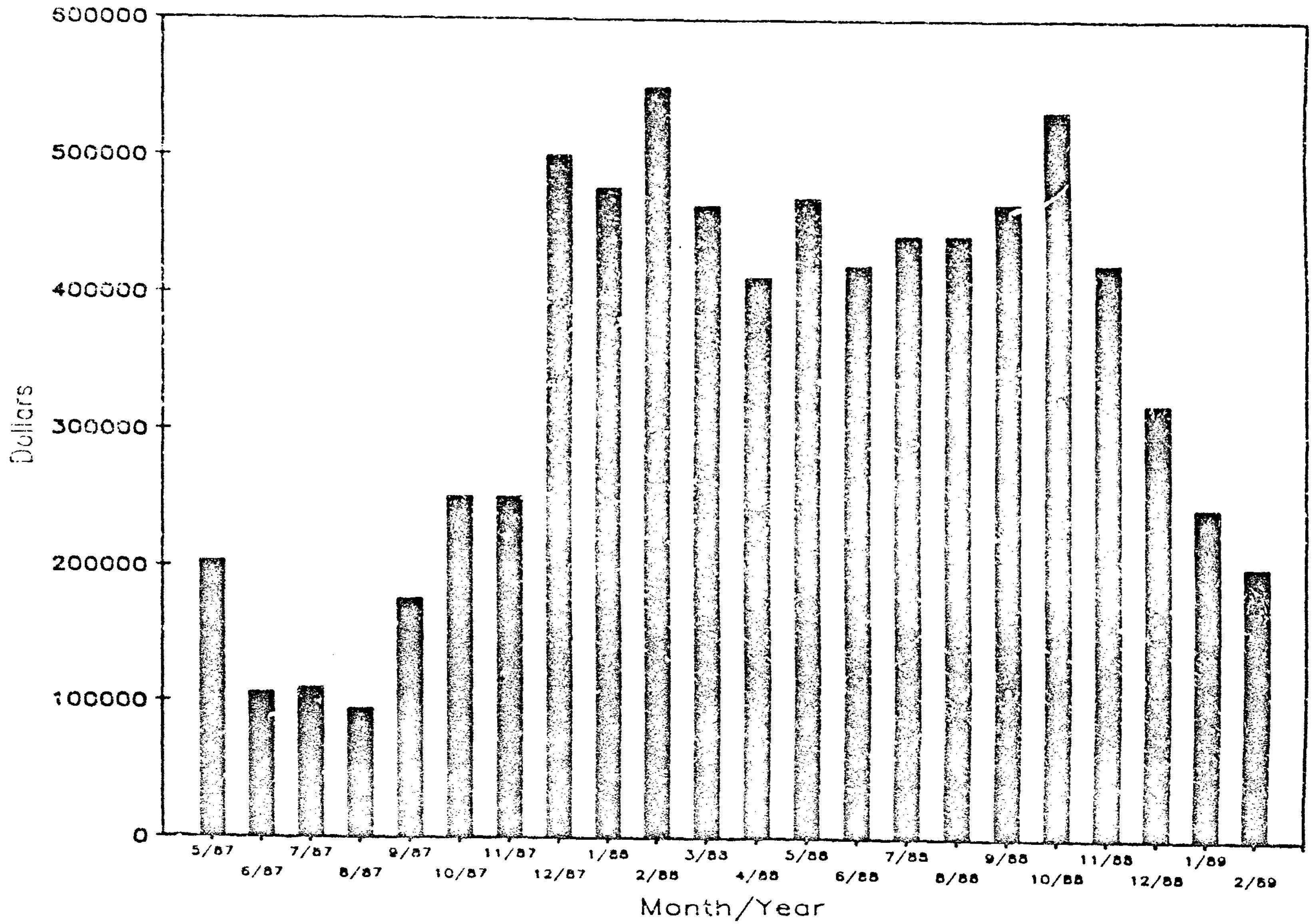

Figure 22. Project Monthly Costs

NCBC Incinerator Project Cost Distribution
May 1987 Through February 1989

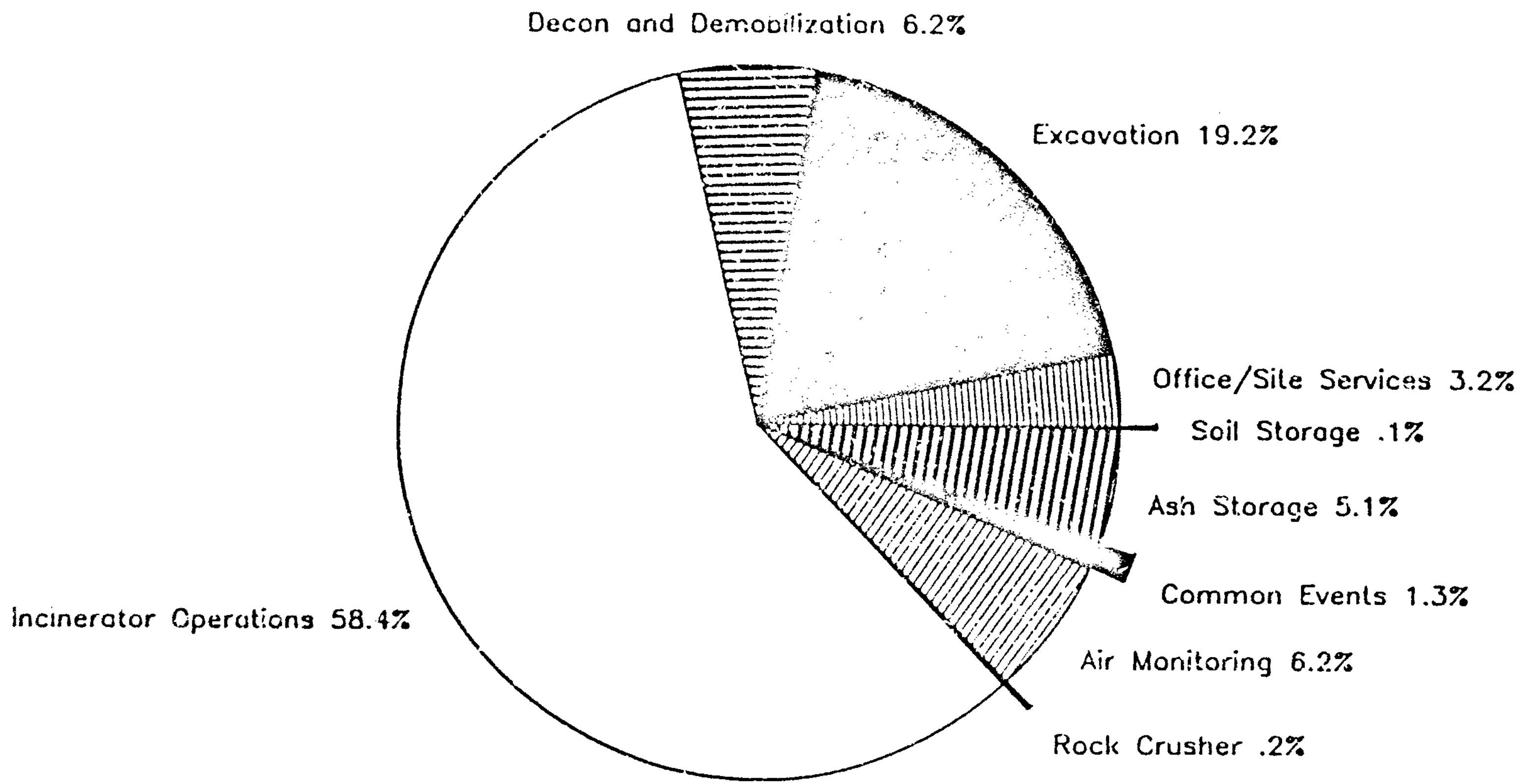

Figure 23. Project Cost Distribution Pie Chart

SECTION VI
ALTERNATE TECHNOLOGIES

On October 3, 1988 the following announcement was placed in the Commerce Business Daily.

> On behalf of the Department of Defense and the Department of Energy, EG&G Idaho is requesting information on pilot- (or full-) scale innovative, currently available technologies to restore contaminated soil and/or ground water to beneficial use at military installations. Contaminants may include halogenated and nonhalogenated aliphatic and aromatic hydrocarbons, organometallic compounds, and inorganic compounds resulting from explosive ordinance disposal. Contamination may also be the result of a single compound or a mixture of compounds resulting from military industrial activities. The field demonstration of the technology will be considered technically successful if the treated material is considered delistable under State and Federal regulations.

In response to the announcement, 25 companies submitted information describing their technologies for the restoration of contaminated soil and/or groundwater at military installation. The most promising technologies still appear to be some type of thermal destruction where the organics are volatilized in the primary system and the gases destroyed in the secondary system. The difference in the proposed technologies from the incineration system used at the NCBC is the primary system heat source. Estimated cost/ton for the proposed technologies was $200 to $250.

One of the responders described an infrared furnace, which was pilot-scale tested at Times Beach, Missouri. A full-scale system has not been field tested. The $200-250/ton costs are estimates only, based on projections of 100-175 tons of soil processed/day.

A second technology using solar heat destruction in a rotary kiln has been bench tested only.

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8. Addendum Report to the Petition for Final Exclusion of F028 Residues Generated During Incineration of F027 Contaminated Soils at the Naval Construction Battalion Center, Gulfport, Mississippi.

9. The Cadmus Group, Inc., Petitions to Delist Hazardous Wastes, a Guidance Manual, EPA/530-SW-85-003, Office of Solid Waste and Emergency Response, April 1985.

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APPENDIX A

NCBC SPREAD SHEETS

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TABLE A-1. AIR MONITORING SPREAD SHEET

NCBC INCINERATION PROJECT
AIR MONITORING
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		MAY 87 $6,063.85	JUNE 87 $2,255.89	JULY 87 $1,525.31	AUG 87 $5,234.58
ITEM EXPENDITURES	UNIT TOTALS				
VERSAR CONTRACT COSTS					
TRAILERS (4)	$324,777.53	6,063.85	2,255.89	703.31	5,234.58
GENERATORS (7)	$2,807.81				
SARTORIUS BALANCE	$16,417.84				
WEATHER STATION	$2,700.00				
ENVIRODYNE - AIR	$5,895.00				
MAINT. COSTS FOR GENERATORS	$134,408.00				
	$2,460.88			822.00	

TABLE A-1. AIR MONITORING SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
AIR MONITORING
MAY 1987 THROUGH FEBRUARY 1989

		SEPT 87	OCT 87	NOV 87	DEC 87
MONTHLY MONETARY TOTALS		$8,180.06	$58,217.15	$45,480.79	$75,904.76
ITEM EXPENDITURES	UNIT TOTALS				
VERSAR CONTRACT COSTS	$324,777.53	8,180.06	33,958.15	26,400.14	53,934.76
TRAILERS (4)	$2,807.81		1,359.00	89.81	
GENERATORS (7)	$16,417.84			11,144.84	
SARTORIUS BALANCE	$2,700.00				2,700.00
WEATHER STATION	$5,895.00				
ENVIRODYNE - AIR	$134,408.00		22,900.00	7,846.00	19,270.00
MAINT. COSTS FOR GENERATORS	$2,460.88				

TABLE A-1. AIR MONITORING SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
AIR MONITORING
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		JAN 88 $51,760.17	FEB 88 $57,537.41	MAR 88 $24,879.08	APRIL 88 $22,590.31
ITEM EXPENDITURES	: UNIT TOTALS :				
VERSAR CONTRACT COSTS	: $324,777.53 :	31,190.17	33,756.17	19,499.68	16,601.16
TRAILERS (4)	: $2,807.81 :				
GENERATORS (7)	: $16,417.84 :		2,597.00	2,610.00	
SARTORIUS BALANCE	: $2,700.00 :				
WEATHER STATION	: $5,895.00 :			524.00	524.00
ENVIRODYNE - AIR	: $134,408.00 :	20,570.00	21,165.00	2,150.00	5,445.00
MAINT. COSTS FOR GENERATORS	: $2,460.88 :		19.24	95.40	20.15

TABLE A-1. AIR MONITORING SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
AIR MONITORING
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		MAY 88 $22,675.03	JUNE 88 $21,256.82	JULY 88 $19,106.97	AUG 88 $21,036.34
ITEM EXPENDITURES	UNIT TOTALS				
VERSAR CONTRACT COSTS	$324,777.53	15,301.03	14,117.82	10,258.97	14,952.34
TRAILERS (4)	$2,807.81			1,359.00	
GENERATORS (7)	$16,417.84				
SARTORIUS BALANCE	$2,700.00				
WEATHER STATION	$5,895.00	524.00	524.00	524.00	524.00
ENVIRODYNE - AIR	$134,408.00	6,850.00	6,615.00	6,965.00	5,560.00
MAINT. COSTS FOR GENERATORS	$2,460.88				

TABLE A-1. AIR MONITORING SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
AIR MONITORING
MAY 1987 THROUGH FEBRUARY 1989

		SEPT 88	OCT 88	NOV 88	DEC 88
MONTHLY MONETARY TOTALS		$12,130.57	$16,170.20	$11,506.98	$2,481.39
ITEM EXPENDITURES	UNIT TOTALS				
VERSAR CONTRACT COSTS	$324,777.53	8,462.95	13,016.13	8,932.98	1,957.39
TRAILERS (4)	$2,807.81				
GENERATORS (7)	$16,417.84				
SARTORIUS BALANCE	$2,700.00				
WEATHER STATION	$5,895.00	524.00	524.00	524.00	524.00
ENVIRODYNE - AIR	$134,408.00	3,100.00	2,400.00	2,050.00	
MAINT. COSTS FOR GENERATORS	$2,460.88	43.62	230.07		

TABLE A-1. AIR MONITORING SPREAD SHEET (CONCLUDED)

NCBC INCINERATION PROJECT
AIR MONITORING
MAY 1987 THROUGH FEBRUARY 1989

		JAN 89	FEB 89
MONTHLY MONETARY TOTALS		$3,342.40	$131.00
ITEM EXPENDITURES	UNIT TOTALS		
VERSAR CONTRACT COSTS	$324,777.53		
TRAILERS (4)	$2,807.81		
GENERATORS (7)	$16,417.84	66.00	
SARTORIUS BALANCE	$2,700.00		
WEATHER STATION	$5,895.00	524.00	131.00
ENVIRODYNE - AIR	$134,408.00	700.00	
MAINT. COSTS FOR GENERATORS	$2,460.88	2,052.40	

TABLE A-2. ASH STORAGE COSTS SPREAD SHEET

NCBC INCINERATION PROJECT
ASH STORAGE COSTS
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		SEPT 87 $2,415.27	OCT 87 $2,500.00	NOV 87 $1,250.00	DEC 87 $17,785.00
ITEM EXPENDITURES	UNIT TOTALS				
ROLL OFF BOXES	$104,790.58				1,696.00
DUMP TRUCK(S)	$45,318.72	1,250.00	2,500.00	1,250.00	1,250.00
TRACK HOE	$29,255.44				
BFI TRANSLIFT TRUCK	$11,879.01	1,165.27			
U.S. TESTING - ASH	$192,907.00				14,839.00

TABLE A-2. ASH STORAGE COSTS SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
ASH STORAGE COSTS
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		JAN 88 $30,887.00	FEB 88 $32,667.07	MAR 88 $31,519.00	APRIL 88 $27,734.40
ITEM EXPENDITURES	: UNIT TOTALS :				
ROLL OFF BOXES	: $104,790.58 :	8,480.00	9,112.00	8,480.00	8,480.00
DUMP TRUCK(S)	: $45,318.72 :	1,950.00	3,100.00	2,900.00	2,118.72
TRACK HOE	: $29,255.44 :	2,968.00	3,055.65	2,650.00	2,296.68
BFI TRANSLIFT TRUCK	: $11,879.01 :	2,650.00	2,560.42	2,650.00	
U.S. TESTING - ASH	: $192,907.00 :	14,839.00	14,839.00	14,839.00	14,839.00

TABLE A-2. ASH STORAGE COSTS SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
ASH STORAGE COSTS
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		MAY 88 $29,092.34	JUNE 88 $28,562.36	JULY 88 $28,515.68	AUG 88 $28,474.03
ITEM EXPENDITURES	: UNIT TOTALS :				
ROLL OFF BOXES	: $104,790.58 :	8,480.00	8,480.00	8,480.00	8,480.00
DUMP TRUCK(S)	: $45,318.72 :	3,300.00	3,300.00	3,300.00	3,300.00
TRACK HOE	: $29,255.44 :	2,473.34	1,943.36	2,296.68	1,855.03
BFI TRANSLIFT TRUCK	: $11,879.01 :				
U.S. TESTING - ASH	: $192,907.00 :	14,839.00	14,839.00	14,839.00	14,839.00

TABLE A-2. ASH STORAGE COSTS SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
ASH STORAGE COSTS
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		SEPT 88 $28,827.35	OCT 88 $28,827.35	NOV 88 $29,269.00	DEC 88 $31,418.86
ITEM EXPENDITURES	: UNIT TOTALS :				
ROLL OFF BOXES	: $104,790.58 :	8,480.00	8,480.00	8,480.00	8,129.86
DUMP TRUCK(S)	: $45,318.72 :	3,300.00	3,300.00	3,300.00	3,300.00
TRACK HOE	: $29,255.44 :	2,208.35	2,208.35	2,650.00	2,650.00
BFI TRANSLIFT TRUCK	: $11,879.01 :				2,500.00
U.S. TESTING - ASH	: $192,907.00 :	14,839.00	14,839.00	14,839.00	14,839.00

TABLE A-2. ASH STORAGE COSTS SPREAD SHEET (CONCLUDED)

NCBC INCINERATION PROJECT
ASH STORAGE COSTS
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		JAN 89 $2,706.04	FEB 89 $1,300.00
ITEM EXPENDITURES	: UNIT TOTALS :		
ROLL OFF BOXES	: $104,790.58 :	1,052.72	
DUMP TRUCK(S)	: $45,318.72 :	1,300.00	1,300.00
TRACK HOE	: $29,255.44 :		
BFI TRANSLIFT TRUCK	: $11,879.01 :	353.32	
U.S. TESTING - ASH	: $192,907.00 :		

TABLE A-3. COMMON EVENTS SPREAD SHEET

NCBC INCINERATION PROJECT
COMMON EVENTS
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		MAY 87 $342.38	JUNE 87 $342.38	JULY 87 $342.38	AUG 87 $342.38
ITEM EXPENDITURES	: UNIT TOTALS :				
BREAK TRAILER	: $7,720.17 :	342.38	342.38	342.38	342.38
FUEL TANKS	: $1,490.08 :				
RADIOS	: $2,071.38 :				
MISCELLANEOUS EQUIPMENT	: $30,574.14 :				
FEDERAL EXPRESS	: $52,123.99 :				
U.P.S.	: $173.64 :				

TABLE A-3. COMMON EVENTS SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
COMMON EVENTS
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		SEPT 87 $1,637.42	OCT 87 $3,389.96	NOV 87 $2,643.12	DEC 87 $5,158.19
ITEM EXPENDITURES	: UNIT TOTALS :				
BREAK TRAILER	: $7,720.17 :	342.38	337.08	342.38	342.38
FUEL TAN	: $1,490.08 :				
RADIOS	: $2,071.38 :				
MISCELLANEOUS EQUIPMENT	: $30,574.14 :	876.45	515.41	1,904.32	1,730.44
FEDERAL EXPRESS	: $52,123.99 :	418.59	2,537.47	396.42	3,085.37
U.P.S.	: $173.64 :				

TABLE A-3. COMMON EVENTS SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
COMMON EVENTS
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		JAN 88 $3,986.95	FEB 88 $8,976.07	MAR 88 $6,770.10	APRIL 88 $3,775.94
ITEM EXPENDITURES	: UNIT TOTALS :				
BREAK TRAILER	: $7,720.17 :	342.38	342.38	367.37	367.37
FUEL TANKS	: $1,490.08 :	100.00	100.00	100.00	100.00
RADIOS	: $2,071.38 :			165.00	165.00
MISCELLANEOUS EQUIPMENT	: $30,574.14 :	1,885.35	3,037.22	1,356.48	522.47
FEDERAL EXPRESS	: $52,123.99 :	1,659.22	5,433.77	4,781.25	2,621.10
U.P.S.	: $173.64 :		62.70		

TABLE A-3. COMMON EVENTS SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
COMMON EVENTS
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		MAY 88 $5,418.87	JUNE 88 $8,288.41	JULY 88 $4,091.10	AUG 88 $7,096.17
ITEM EXPENDITURES	: UNIT TOTALS :				
BREAK TRAILER	: $7,720.17 :	359.43	369.89	344.51	344.06
FUEL TANKS	: $1,490.08 :	100.00	190.08	100.00	100.00
RADIOS	: $2,071.38 :	165.00	165.00	165.00	165.00
MISCELLANEOUS EQUIPMENT	: $30,574.14 :	1,649.55	1,775.53	1,709.52	1,821.18
FEDERAL EXPRESS	: $52,123.99 :	3,144.89	5,787.91	1,772.07	4,665.93
U.P.S.	: $173.64 :				

TABLE A-3. COMMON EVENTS SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
COMMON EVENTS
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		SEPT 88 $5,265.84	OCT 88 $7,955.74	NOV 88 $5,493.16	DEC 88 $4,799.53
ITEM EXPENDITURES	: UNIT TOTALS :				
BREAK TRAILER	: $7,720.17 :	344.73	344.70	344.66	344.07
FUEL TANKS	: $1,490.08 :	100.00	100.00	100.00	100.00
RADIOS	: $2,071.38 :	165.00	165.00	252.95	292.18
MISCELLANEOUS EQUIPMENT	: $30,574.14 :	1,899.25	1,839.57	2,201.16	2,435.53
FEDERAL EXPRESS	: $52,123.99 :	2,756.86	5,506.47	2,594.39	1,627.75
U.P.S.	: $173.64 :				

TABLE A-3. COMMON EVENTS SPREAD SHEET (CONCLUDED)

NCBC INCINERATION PROJECT
COMMON EVENTS
MAY 1987 THROUGH FEBRUARY 1989

		JAN 89	FEB 89
MONTHLY MONETARY TOTALS		$5,458.42	$2,578.89
ITEM EXPENDITURES	UNIT TOTALS		
BREAK TRAILER	$7,720.17	351.07	419.81
FUEL TANKS	$1,490.08	100.00	100.00
RADIOS	$2,071.38	165.00	41.25
MISCELLANEOUS EQUIPMENT	$30,574.14	2,370.69	1,044.02
FEDERAL EXPRESS	$52,123.99	2,471.66	862.87
U.P.S.	$173.64		110.94

TABLE A-4. DECONTAMINATION AND DEMOBILIZATION SPREAD SHEET

NCBC INCINERATION PROJECT
DECONTAMINATION AND DEMOBILIZATION
MAY 1987 THROUGH FEBRUARY 1989

		SEPT 87	OCT 87	NOV 87	DEC 87
MONTHLY MONETARY TOTALS		$0.00	$1,644.00	$1,290.00	$0.00
ITEM EXPENDITURES	UNIT TOTALS				
DECON. PAD MATERIAL	$3,393.10				
LABOR TO BUILD PAD	$3,740.00				
LABOR TO CLEAN EQUIPMENT	$15,870.00				
LABOR TO TAKE SWIPE SAMPLES	$2,225.00				
ENVIRODYNE - SWIPES	$83,646.00		1,644.00	1,290.00	
ABC RENTAL	$2,072.08				
HERTZ RENTAL	$2,887.35				
EQUIP RENTAL	$12,069.03				
LABOR TO DISMANTLE	$217,449.05				
MATERIALS	$27,650.43				
TRIAL/BURN SAND DISPOSAL	$44,607.40				
REFRACTORY DISPOSAL	$6,323.75				
ACE TRANSPORTATION	$42,416.45				

TABLE A-4. DECONTAMINATION AND DEMOBILIZATION SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
DECONTAMINATION AND DEMOBILIZATION
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		JAN 88 $0.00	FEB 88 $0.00	MAR 88 $1,370.00	APRIL 88 $0.00
ITEM EXPENDITURES	UNIT TOTALS				
DECON. PAD MATERIAL	$3,393.10				
LABOR TO BUILD PAD	$3,740.00				
LABOR TO CLEAN EQUIPMENT	$15,870.00				
LABOR TO TAKE SWIPE SAMPLES	$2,225.00				
ENVIRODYNE - SWIPES	$83,646.00				
ABC RENTAL	$2,072.08			1,370.00	
HERTZ RENTAL	$2,887.35				
EQUIP RENTAL	$12,069.03				
LABOR TO DISMANTLE	$217,449.05				
MATERIALS	$27,650.43				
TRIAL/BURN SAND DISPOSAL	$44,607.40				
REFRACTORY DISPOSAL	$6,323.75				
ACE TRANSPORTATION	$42,416.45				

TABLE A-4. DECONTAMINATION AND DEMOBILIZATION SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
DECONTAMINATION AND DEMOBILIZATION
MAY 1987 THROUGH FEBRUARY 1989

		MAY 88	JUNE 88	JULY 88	AUG 88
MONTHLY MONETARY TOTALS		$0.00	$0.00	$25.00	$0.00
ITEM EXPENDITURES	UNIT TOTALS				
DECON. PAD MATERIAL	$3,393.10				
LABOR TO BUILD PAD	$3,740.00				
LABOR TO CLEAN EQUIPMENT	$15,870.00				
LABOR TO TAKE SWIPE SAMPLES	$2,225.00			25.00	
ENVIRODYNE - SWIPES	$83,646.00				
ABC RENTAL	$2,072.08				
HERTZ RENTAL	$2,887.35				
EQUIP RENTAL	$12,069.03				
LABOR TO DISMANTLE	$217,449.05				
MATERIALS	$27,650.43				
TRIAL/BURN SAND DISPOSAL	$44,607.40				
REFRACTORY DISPOSAL	$6,323.75				
ACE TRANSPORTATION	$42,416.45				

TABLE A-4. DECONTAMINATION AND DEMOBILIZATION SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
DECONTAMINATION AND DEMOBILIZATION
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		SEPT 88 $6,556.00	OCT 88 $57,503.60	NOV 88 $27,800.68	DEC 88 $79,128.08
ITEM EXPENDITURES	: UNIT TOTALS :				
DECON. PAD MATERIAL	: $3,393.10 :		3,393.10		
LABOR TO BUILD PAD	: $3,740.00 :	2,000.00		1,740.00	
LABOR TO CLEAN EQUIPMENT	: $15,870.00 :	680.00	700.00	2,750.00	10,380.00
LABOR TO TAKE SWIPE SAMPLES	: $2,225.00 :	40.00	100.00		1,856.00
ENVIRODYNE - SWIPES	: $83,646.00 :	3,836.00	4,110.00	8,768.00	822.00
ABC RENTAL	: $2,072.08 :				
HERTZ RENTAL	: $2,887.35 :				
EQUIP RENTAL	: $12,069.03 :		1,200.00	1,200.00	1,200.00
LABOR TO DISMANTLE	: $217,449.05 :			13,310.88	63,977.05
MATERIALS	: $27,650.43 :		3,393.10	31.80	893.03
TRIAL/BURN SAND DISPOSAL	: $44,607.40 :		44,607.40		
REFRACTORY DISPOSAL	: $6,323.75 :				
ACE TRANSPORTATION	: $42,416.45 :				

TABLE A-4 DECONTAMINATION AND DEMOBILIZATION SPREAD SHEET (CONCLUDED)

NCBC INCINERATION PROJECT
DECONTAMINATION AND DEMOBILIZATION
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		JAN 89 $139,162.76	FEB 89 $149,869.50
ITEM EXPENDITURES	UNIT TOTALS		
DECON. PAD MATERIAL	$3,393.10		
LABOR TO BUILD PAD	$3,740.00		
LABOR TO CLEAN EQUIPMENT	$15,870.00	1,360.00	
LABOR TO TAKE SWIPE SAMPLES	$2,225.00	204.00	
ENVIRODYNE - SWIPES	$83,646.00	31,392.00	30,414.00
ABC RENTAL	$2,072.08		2,072.08
HERTZ RENTAL	$2,887.35		2,887.35
EQUIP RENTAL	$12,069.03	4,486.00	3,983.03
LABOR TO DISMANTLE	$217,449.05	95,491.87	44,669.25
MATERIALS	$27,650.43	6,228.91	17,103.59
TRIAL/BURN SAND DISPOSAL	$44,607.40		
REFRACTORY DISPOSAL	$6,323.75		6,323.75
ACE TRANSPORTATION	$42,416.45		42,416.45

TABLE A-[illegible]. EXCAVATION SPREAD SHEET

NCBC INCINERATION PROJECT
EXCAVATION
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		MAY 87 $779.08	JUNE 87 $337.08	JULY 87 $337.08	AUG 87 $337.08
ITEM EXPENDITURES	UNIT TOTALS				
DOZER	$24,062.00				
TRACK HOE	$15,141.53				
LIGHT TOWERS	$17,172.00				
SAMPLE TRAILER	$9,257.09	337.08	337.08	337.08	337.08
STORAGE TRAILER	$4,892.34	442.00			
LABOR FOR EXCAVATION DAYS	$147,049.00				
ENVIRODYNE - SOIL	$486,129.00				
U.S. TESTING - SOIL	$532,308.00				
TWIN CITIES	$67,592.98				
I.T.	$100,655.03				
FRONT END LOADER	$42,417.67				
DUMP TRUCK	$16,455.98				
PLANER (MAINT/REFURB)	$18,462.07				
FILL DIRT	$10,208.00				
MATERIALS	$46,190.23				

TABLE A-5. EXCAVATION SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
EXCAVATION
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		SEPT 87 $7,908.49	OCT 87 $12,742.86	NOV 87 $23,287.82	DEC 87 $111,657.00
ITEM EXPENDITURES	UNIT TOTALS				
DOZER	$24,062.00			1,696.00	1,696.00
TRACK HOE	$15,141.53	2,700.00	2,862.00	2,862.00	3,096.00
LIGHT TOWERS	$17,172.00				
SAMPLE TRAILER	$9,257.09	337.08	337.08	337.08	337.08
STORAGE TRAILER	$4,892.34	337.08	177.00	1,306.00	176.60
LABOR FOR EXCAVATION DAYS	$147,049.00				1,654.00
ENVIRODYNE - SOIL	$486,129.00				40,510.75
U.S. TESTING - SOIL	$532,308.00				44,359.00
TWIN CITIES	$67,592.98				
I.T.	$100,655.03			14,379.29	14,379.29
FRONT END LOADER	$42,417.67	2,597.00	2,597.00	2,597.00	2,597.00
DUMP TRUCK	$16,455.98				1,250.00
PLANER (MAINT/REFURB)	$18,462.07				
FILL DIRT	$10,208.00				
MATERIALS	$46,190.23	1,937.33	6,769.78	110.45	1,601.28

TABLE A-5. EXCAVATION SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
EXCAVATION
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		JAN 88 $122,823.73	FEB 88 $118,675.02	MAR 88 $114,198.46	APRIL 88 $118,490.79
ITEM EXPENDITURES	UNIT TOTALS				
DOZER	$24,062.00				
TRACK HOE	$15,141.53	2,014.00	1,696.00	1,696.00	1,696.00
LIGHT TOWERS	$17,172.00		88.33	264.99	353.32
SAMPLE TRAILER	$9,257.09	337.08	999.20	334.96	348.96
STORAGE TRAILER	$4,892.34	176.59	338.23	183.55	196.26
LABOR FOR EXCAVATION DAYS	$147,049.00	13,308.00	9,595.00	8,489.00	10,049.00
ENVIRODYNE - SOIL	$486,129.00	40,510.75	40,510.75	40,510.75	40,510.75
U.S. TESTING - SOIL	$532,308.00	44,359.00	44,359.00	44,359.00	44,359.00
TWIN CITIES	$67,592.98				
I.T.	$100,655.03				
FRONT END LOADER	$42,417.67	14,379.29	14,379.29	14,379.29	14,379.29
DUMP TRUCK	$16,455.98	2,597.00	2,597.00	2,597.00	2,597.00
PLANER (MAINT/REFURB)	$18,462.07	1,250.00	1,250.00	1,250.00	1,250.00
FILL DIRT	$10,208.00				
MATERIALS	$46,190.23	3,892.02	2,862.22	133.92	2,751.21

TABLE A-5. EXCAVATION SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
EXCAVATION
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		MAY 88 $136,198.25	JUNE 88 $121,165.09	JULY 88 $125,534.14	AUG 88 $120,270.34
ITEM EXPENDITURES	UNIT TOTALS				
DOZER	$24,062.00	1,696.00	1,696.00	1,696.00	1,696.00
TRACK HOE	$15,141.53	176.66	706.64	353.32	794.97
LIGHT TOWERS	$17,172.00		1,908.00	1,908.00	1,908.00
SAMPLE TRAILER	$9,257.09	359.43	369.89	349.00	575.46
STORAGE TRAILER	$4,892.34	196.26	196.26	166.84	165.68
LABOR FOR EXCAVATION DAYS	$147,049.00	16,241.00	14,247.00	15,251.00	11,692.00
ENVIRODYNE - SOIL	$486,129.00	40,510.75	40,510.75	40,510.75	40,510.75
U.S. TESTING - SOIL	$532,308.00	44,359.00	44,359.00	44,359.00	44,359.00
TWIN CITIES	$67,592.98	9,656.14	9,656.14	9,656.14	9,656.14
I.T.	$100,655.03	14,379.29			
FRONT END LOADER	$42,417.67	2,597.00	2,597.00	2,597.00	2,597.00
DUMP TRUCK	$16,455.98	1,250.00	1,250.00	1,250.00	1,250.00
PLANER (MAINT/REFURB)	$18,462.07	73.33		462.86	2,938.57
FILL DIRT	$10,208.00				
MATERIALS	$46,190.23	4,703.39	3,668.41	6,974.23	2,126.77

TABLE A-5. EXCAVATION SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
EXCAVATION
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		SEPT 88 $117,775.47	OCT 88 $128,161.58	NOV 88 $127,064.22	DEC 88 $11,375.00
ITEM EXPENDITURES	UNIT TOTALS				
DOZER	$24,062.00	1,696.00	1,696.00	1,696.00	1,696.00
TRACK HOE	$15,141.53	441.65	441.65		
LIGHT TOWERS	$17,172.00	1,908.00	1,908.00	1,908.00	1,908.00
SAMPLE TRAILER	$9,257.09	573.93	369.89	575.45	368.00
STORAGE TRAILER	$4,892.34	165.66	165.66	164.44	
LABOR FOR EXCAVATION DAYS	$147,049.00	12,516.00	19,291.00	11,160.00	3,556.00
ENVIRODYNE - SOIL	$486,129.00	40,510.75	40,510.75	40,510.75	
U.S. TESTING - SOIL	$532,308.00	44,359.00	44,359.00	44,359.00	
TWIN CITIES	$67,592.98	9,656.14	9,656.14	9,656.14	
I.T.	$100,655.03				
FRONT END LOADER	$42,417.67	2,597.00	2,597.00	2,597.00	2,597.00
DUMP TRUCK	$16,455.98	1,250.00	1,250.00	1,455.98	1,250.00
PLANER (MAINT/REFURB)	$18,462.07		1,928.12	203.96	
FILL DIRT	$10,208.00		487.50	9,720.50	
MATERIALS	$46,190.23	2,101.34	3,500.87	3,057.01	

TABLE A-5. EXCAVATION SPREAD SHEET (CONCLUDED)

NCBC INCINERATION PROJECT
EXCAVATION
MAY 1987 THROUGH FEBRUARY 1989

		JAN 89	FEB 89
MONTHLY MONETARY TOTALS		$4,111.10	$14,763.23
ITEM EXPENDITURES	UNIT TOTALS		
DOZER	$24,062.00		
TRACK HOE	$15,141.53		
LIGHT TOWERS	$17,172.00	1,908.00	1,908.00
SAMPLE TRAILER	$9,257.09	999.20	
STORAGE TRAILER	$4,892.34	338.23	
LABOR FOR EXCAVATION DAYS	$147,049.00		
ENVIRODYNE - SOIL	$486,129.00		
U.S. TESTING - SOIL	$532,308.00		
TWIN CITIES	$67,592.98		
I.T.	$100,655.03		
FRONT END LOADER	$42,417.67	865.67	
DUMP TRUCK	$16,455.98		
PLANER (MAINT/REFURB)	$18,462.07		12,855.23
FILL DIRT	$10,208.00		
MATERIALS	$46,190.23		

TABLE A-6. INCINERATOR OPERATIONS SPREAD SHEET

NCBC INCINERATION PROJECT
INCINERATOR OPERATIONS
MAY 1987 THROUGH FEBRUARY 1989

		MAY 87	JUNE 87	JULY 87	AUG 87
MONTHLY MONETARY TOTALS		$191,169.31	$102,017.69	$106,564.48	$87,299.00
ITEM EXPENDITURES	UNIT TOTALS				
INCINERATOR LEASE	$1,501,632.50	87,299.00	87,299.00	87,299.00	87,299.00
ABC RENTAL	$7,268.86	1,442.00	46.00		
HERTZ RENTAL	$37,153.54	6,163.00			
LABOR	$1,018,804.00	62,111.00			
NATURAL GAS	$974,144.52	18,780.84	12,978.90	18,946.24	
WATER	$14,749.02	1,959.85	1,375.13		
SEWAGE	$3,392.93				
ELECTRICITY	$87,447.49	306.12	318.66	319.24	
FRONT END LOADER	$83,936.62				
FORKLIFT	$26,673.94				
MATERIALS	$612,205.86	13,107.50			

TABLE A-6. INCINERATOR OPERATIONS SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
INCINERATOR OPERATIONS
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		SEPT 87 $149,524.98	OCT 87 $164,294.68	NOV 87 $176,943.55	DEC 87 $272,582.63
ITEM EXPENDITURES	UNIT TOTALS				
INCINERATOR LEASE	$1,501,632.50	87,299.00	87,299.00	87,299.00	87,299.00
ABC RENTAL	$7,268.86		187.62		612.00
HERTZ RENTAL	$37,153.54		1,496.00	2,793.10	6,005.00
LABOR	$1,018,804.00	46,645.00	52,093.00	71,529.00	65,879.00
NATURAL GAS	$974,144.52		3,322.50		84,825.64
WATER	$14,749.02		33.25	2.85	813.20
SEWAGE	$3,392.93		19.95	1.42	487.82
ELECTRICITY	$87,447.49		269.09	289.65	2,794.22
FRONT END LOADER	$83,936.62	945.00	2,597.00		4,717.00
FORKLIFT	$26,673.94	1,500.00	581.94	2,120.00	2,720.00
MATERIALS	$612,205.86	13,135.98	16,395.33	12,908.53	16,429.75

TABLE A-6. INCINERATOR OPERATIONS SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
INCINERATOR OPERATIONS
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		JAN 88 $249,208.53	FEB 88 $313,908.84	MAR 88 $273,385.15	APRIL 88 $224,029.36
ITEM EXPENDITURES	: UNIT TOTALS :				
INCINERATOR LEASE	:$1,501,632.50 :	60,371.00	59,371.00	61,549.00	61,549.00
ABC RENTAL	: $7,268.86 :		107.38	45.58	292.56
HERTZ RENTAL	: $37,153.54 :	2,968.00	7,935.11	2,666.10	5,510.62
LABOR	:$1,018,804.00 :	77,170.00	63,484.00	61,927.00	47,054.00
NATURAL GAS	: $974,144.52 :	67,129.00	75,606.00	83,199.83	61,705.83
WATER	: $14,749.02 :	635.00	766.00	846.93	901.08
SEWAGE	: $3,392.93 :	380.00	459.00	507.78	540.55
ELECTRICITY	: $87,447.49 :	5,282.22	5,946.81	4,852.51	6,037.24
FRONT END LOADER	: $83,936.62 :	2,597.00	2,597.00	2,597.00	5,247.00
FORKLIFT	: $25,673.94 :	2,150.00	2,905.00	2,507.00	1,097.10
MATERIALS	: $612,205.86 :	30,526.31	94,731.54	52,686.42	34,094.38

TABLE A-6. INCINERATOR OPERATIONS SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
INCINERATOR OPERATIONS
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		MAY 88 $263,942.83	JUNE 88 $228,984.28	JULY 88 $250,497.81	AUG 88 $246,783.09
ITEM EXPENDITURES	: UNIT TOTALS :				
INCINERATOR LEASE	:$1,501,632.50 :	61,549.00	61,549.00	61,549.00	61,549.00
ABC RENTAL	: $7,268.86 :	199.02			405.88
HERTZ RENTAL	: $37,153.54 :		568.88		
LABOR	:$1,018,804.00 :	78,821.00	51,369.00	70,039.00	62,723.00
NATURAL GAS	: $974,144.52 :	65,959.08	73,595.67	68,267.10	63,663.57
WATER	: $14,749.02 :	1,149.03	1,241.18	1,073.98	795.63
SEWAGE	: $3,392.93 :				
ELECTRICITY	: $87,447.49 :	5,761.73	6,895.37	7,138.87	8,124.63
FRONT END LOADER	: $83,936.62 :	5,247.00	5,247.00	5,247.00	5,247.00
FORKLIFT	: $26,673.94 :	1,097.10	1,219.00	1,097.10	1,097.10
MATERIALS	: $612,205.86 :	44,159.87	27,299.18	36,085.76	43,177.28

TABLE A-6. INCINERATOR OPERATIONS SPREAD SHEET (CONTINUED)

NCBC [illegible]CINERATION PROJECT
IN[illegible]RATOR OPERATIONS
MAY 19[illegible] THROUGH FEBRUARY 1989

MON[illegible]LY MONETARY TOTALS		SEPT 88 $285,207.06	OCT 88 $280,458.19	NOV 88 $212,813.27	DEC 88 $182,171.88
[illegible]TEM EXPENDITURES	: UNIT TOTALS :				
INC[illegible]RATOR LEASE	:$1,501,632.50 :	59,882.00	59,882.00	59,882.00	59,882.00
ABC [illegible]NTAL	: $7,268.86 :	906.57	638.63	621.35	1,196.16
HER[illegible] RENTAL	: $37,153.54 :				
LA[illegible]	:$1,018,804.00 :				
NA[illegible]AL GAS	: $974,144.52 :	59,490.00	75,307.00	57,917.00	15,246.00
W[illegible]	: $14,749.02 :	61,589.79	82,441.98	56,925.63	75,206.92
S[illegible]GE	: $3,392.93 :	702.05	944.30	646.00	722.48
EL[illegible]TRICITY	: $87,447.49 :				
F[illegible]NT END LOADER	: $83,936.62 :	6,240.81	6,803.02	7,469.37	6,576.40
F[illegible]KLIFT	: $26,673.94 :	5,247.00	11,937.46	8,586.00	8,586.00
MATERIALS	: $612,205.86 :	1,097.10	1,097.10	1,097.10	1,097.10
		90,051.74	41,406.70	19,668.82	13,658.82

TABLE A-6. INCINERATOR OPERATIONS SPREAD SHEET (CONCLUDED)

NCBC INCINERATION PROJECT
INCINERATOR OPERATIONS
MAY 1987 THROUGH FEBRUARY 1989

		JAN 89	FEB 89
MONTHLY MONETARY TOTALS		$79,969.11	$25,653.56
ITEM EXPENDITURES	UNIT TOTALS		
INCINERATOR LEASE	$1,501,632.50	59,882.00	14,794.50
ABC RENTAL	$7,268.86	319.06	249.05
HERTZ RENTAL	$37,153.54		1,047.73
LABOR	$1,018,804.00		
NATURAL GAS	$974,144.52		
WATER	$14,749.02	141.08	
SEWAGE	$3,392.93		996.41
ELECTRICITY	$87,447.49	5,244.44	777.09
FRONT END LOADER	$83,936.62	3,339.00	3,956.16
FORKLIFT	$26,673.94	1,097.10	1,097.10
MATERIALS	$612,205.86	9,946.43	2,735.52

A-7. OFFICE/SITE SERVICES SPREAD SHEET

NCBC INCINERATION PROJECT
OFFICE/SITE SERVICES
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		MAY 87 $6,134.62	JUNE 87 $1,942.11	JULY 87 $1,552.65	AUG 87 $1,748.08
ITEM EXPENDITURES	: UNIT TOTALS :				
OFFICE TRAILER/EG&G TRAILER :	$10,355.06 :	625.00			233.00
BEUTILITE TRAILER :	$13,758.80 :	625.40	625.40	625.40	625.40
EPA GUEST TRAILER :	$5,614.52 :				
OFFICE FURNITURE :	$9,495.00 :				
OFFICE EQUIPMENT :	$6,222.00 :	133.00			
TELEPHONE LINE CHARGES :	$43,918.61 :	2,394.22	1,316.71	927.25	889.68
LABOR :	$120,787.00 :	2,357.00			
TELEPHONE SYSTEM PURCHASE :	$4,158.10 :				
COMPUTERS :	$3,623.53 :				
OFFICE SUPPLIES :	$22,423.43 :				

A-7. OFFICE/SITE SERVICES SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
OFFICE/SITE SERVICES
MAY 1987 THROUGH FEBRUARY 1989

		SEPT 87	OCT 87	NOV 87	DEC 87
MONTHLY MONETARY TOTALS		$7,172.63	$13,242.15	$9,061.11	$12,249.63
ITEM EXPENDITURES	: UNIT TOTALS :				
OFFICE TRAILER/EG&G TRAILER	: $10,355.06 :	101.00	342.00	342.00	342.00
BEUTILITE TRAILER	: $13,758.80 :	625.40	625.40	625.40	625.40
EPA GUEST TRAILER	: $5,614.52 :			342.38	342.38
OFFICE FURNITURE	: $9,495.00 :	245.00	1,129.00		545.00
OFFICE EQUIPMENT	: $6,222.00 :	239.00	318.00	239.00	608.00
TELEPHONE LINE CHARGES	: $43,918.61 :	1,487.75	2,033.09	2,915.51	2,888.81
LABOR	: $120,787.00 :	3,911.00	7,534.00	4,543.00	5,528.00
TELEPHONE SYSTEM PURCHASE	: $4,158.10 :		342.50		
COMPUTERS	: $3,623.53 :		116.60		
OFFICE SUPPLIES	: $22,423.43 :	563.48	801.56	53.82	1,370.04

A-7. OFFICE/SITE SERVICES SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
OFFICE/SITE SERVICES
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		JAN 88 $16,868.13	FEB 88 $19,308.01	MAR 88 $14,005.60	APRIL 88 $16,404.75
ITEM EXPENDITURES	UNIT TOTALS				
OFFICE TRAILER/EG&G TRAILER	$10,355.06	344.00	334.00	340.00	1,779.00
BEUTILITE TRAILER	$13,758.80	625.40	625.40	625.40	625.40
EPA GUEST TRAILER	$5,614.52	342.38	367.00	368.00	368.00
OFFICE FURNITURE	$9,495.00	734.00	1,178.00	444.00	539.00
OFFICE EQUIPMENT	$6,222.00	239.00	1,073.00	238.50	238.50
TELEPHONE LINE CHARGES	$43,918.61	2,584.00	2,740.80	2,591.38	2,631.34
LABOR	$120,787.00	8,293.00	8,298.00	8,141.00	7,272.00
TELEPHONE-SYSTEM PURCHASE	$4,158.10	1,971.00		300.00	
COMPUTERS	$3,623.53	339.90	770.00	100.00	810.72
OFFICE SUPPLIES	$22,423.43	1,395.45	3,921.81	857.32	2,140.79

A-7. OFFICE/SITE SERVICES SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
OFFICE/SITE SERVICES
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		MAY 88 $12,905.89	JUNE 88 $11,083.19	JULY 88 $15,174.52	AUG 88 $15,179.77
ITEM EXPENDITURES	UNIT TOTALS				
OFFICE TRAILER/EG&G TRAILER	$10,355.06	368.00	1,040.00	350.00	350.53
BEUTILITE TRAILER	$13,758.80	625.40	625.40	625.40	625.40
EPA GUEST TRAILER	$5,614.52	368.00	368.00	344.00	344.00
OFFICE FURNITURE	$9,495.00	661.00	502.00	444.00	579.00
OFFICE EQUIPMENT	$6,222.00	238.50	238.50	238.50	238.50
TELEPHONE LINE CHARGES	$43,918.61	2,176.55	1,999.85	2,041.43	2,111.93
LABOR	$120,787.00	6,942.00	5,112.00	7,818.00	7,589.00
TELEPHONE SYSTEM PURCHASE	$4,158.10	102.60			
COMPUTERS	$3,623.53	821.32			854.00
OFFICE SUPPLIES	$22,423.43	602.52	58.12 1,139.32	58.12 3,255.07	243.62 2243.79

A-7. OFFICE/SITE SERVICES SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
OFFICE/SITE SERVICES
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		SEPT 88 $11,592.40	OCT 88 $14,984.07	NOV 88 $10,153.36	DEC 88 $9,763.86
ITEM EXPENDITURES	UNIT TOTALS				
OFFICE TRAILER/EG&G TRAILER	$10,355.06	350.53	344.00	350.00	350.00
BEUTILITE TRAILER	$13,758.80	625.40	625.40	625.40	625.40
EPA GUEST TRAILER	$5,614.52	344.00	344.00	342.38	344.00
OFFICE FURNITURE	$9,495.00	579.00	579.00	515.00	135.00
OFFICE EQUIPMENT	$6,222.00	600.00	476.00	628.00	238.00
TELEPHONE LINE CHARGES	$43,918.61	1,978.26	2,081.42	1,806.59	1,779.96
LABOR	$120,787.00	6,566.00	8,117.00	5,237.00	5,962.00
TELEPHONE SYSTEM PURCHASE	$4,158.10		588.00		
COMPUTERS	$3,623.53	58.12	58.12	58.12	58.12
OFFICE SUPPLIES	$22,423.43	491.09	1,771.13	590.87	271.38

A-7. OFFICE/SITE SERVICES SPREAD SHEET (CONCLUDED)

NCBC INCINERATION PROJECT
OFFICE/SITE SERVICES
MAY 1987 THROUGH FEBRUARY 1989

		JAN 89	FEB 89
MONTHLY MONETARY TOTALS		$11,076.63	$8,752.89
ITEM EXPENDITURES	UNIT TOTALS		
OFFICE TRAILER/EG&G TRAILER	$10,355.06	694.00	1,376.00
3EUTILITE TRAILER	$13,758.80	625.40	625.40
EPA GUEST TRAILER	$5,614.52	344.00	342.00
OFFICE FURNITURE	$9,495.00		687.00
OFFICE EQUIPMENT	$6,222.00		
TELEPHONE LINE CHARGES	$43,918.61	1,753.67	788.41
LABOR	$120,787.00	7,061.00	4,506.00
TELEPHONE SYSTEM PURCHASE	$4,158.10		
COMPUTERS	$3,623.53	58.12	14.53
OFFICE SUPPLIES	$22,423.43	540.44	413.55

A-8. ROCK CRUSHER SPREAD SHEET

NCBC INCINERATION PROJECT
ROCK CRUSHER
MAY 1987 THROUGH FEBRUARY 1989

		JAN 88	FEB 88	MAR 88	APRIL 88
MONTHLY MONETARY TOTALS		$2,073.26	$936.00	$816.00	$873.00
ITEM EXPENDITURES	: UNIT TOTALS :				
SET UP LABOR	: $1,752.00 :		936.00	816.00	
SET UP MATERIAL	: $2,073.26 :	2,073.26			
OPERATIONAL LABOR	: $7,313.00 :				873.00
LEASE RATE	: $3,921.80 :				

A-8. ROCK CRUSHER SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
ROCK CRUSHER
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		MAY 88 $1,330.45	JUNE 88 $3,230.45	JULY 88 $980.45	AUG 88 $4,580.45
ITEM EXPENDITURES	UNIT TOTALS				
SET UP LABOR	$1,752.00				
SET UP MATERIAL	$2,073.26				
OPERATIONAL LABOR	$7,313.00	350.00	2,250.00		3,600.00
LEASE RATE	$3,921.80	980.45	980.45	980.45	980.45

A-8. ROCK CRUSHER SPREAD SHEET (CONCLUDED)

NCBC INCINERATION PROJECT
ROCK CRUSHER
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		SEPT 88 $240.00	OCT 88 $0.00	NOV 88 $0.00	DEC 88 $0.00
ITEM EXPENDITURES	UNIT TOTALS				
SET UP LABOR	$1,752.00				
SET UP MATERIAL	$2,073.26				
OPERATIONAL LABOR	$7,313.00	240.00			
LEASE RATE	$3,921.80				

TABLE A-9. SOIL STORAGE COSTS SPREAD SHEET

NCBC INCINERATION PROJECT
SOIL STORAGE COSTS
MAY 1987 THROUGH FEBRUARY 1989

			SEPT 87	OCT 87	NOV 87	DEC 87
MONTHLY MONETARY TOTALS			$0.00	$0.00	$0.00	$7,140.36
ITEM EXPENDITURES	: UNIT TOTALS	:				
TENTS (3)	: $6,284.91	:				4,976.71
LABOR TO SET UP	: $2,592.00	:				1,728.00
LABOR TO REPAIR TENTS	: $1,344.00	:				
LABOR TO BUILD SIDEWALLS	: $432.00	:				144.00
MATERIAL TO BUILD SIDEWALLS	: $291.65	:				291.65

TABLE A-9. SOIL STORAGE COSTS SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
SOIL STORAGE COSTS
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		JAN 88 $1,008.00	FEB 88 $144.00	MAR 88 $0.00	APRIL 88 $0.00
ITEM EXPENDITURES	UNIT TOTALS				
TENTS (3)	$6,284.91				
LABOR TO SET UP	$2,592.00	864.00			
LABOR TO REPAIR TENTS	$1,344.00				
LABOR TO BUILD SIDEWALLS	$432.00	144.00	144.00		
MATERIAL TO BUILD SIDEWALLS	$291.65				

TABLE A-9. SOIL STORAGE COSTS SPREAD SHEET (CONTINUED)

NCBC INCINERATION PROJECT
SOIL STORAGE COSTS
MAY 1987 THROUGH FEBRUARY 1989

		MAY 88	JUNE 88	JULY 88	AUG 88
MONTHLY MONETARY TOTALS		$192.00	$0.00	$0.00	$1,152.00
ITEM EXPENDITURES	UNIT TOTALS				
TENTS (3)	$6,284.91				
LABOR TO SET UP	$2,592.00				
LABOR TO REPAIR TENTS	$1,344.00	192.00			1,152.00
LABOR TO BUILD SIDEWALLS	$432.00				
MATERIAL TO BUILD SIDEWALLS	$291.65				

TABLE A-9. SOIL STORAGE COSTS SPREAD SHEET (CONCLUDED)

NCBC INCINERATION PROJECT
SOIL STORAGE COSTS
MAY 1987 THROUGH FEBRUARY 1989

MONTHLY MONETARY TOTALS		SEPT 88	OCT 88	NOV 88	DEC 88
		$0.00	$1,308.20	$0.00	$0.00
ITEM EXPENDITURES	UNIT TOTALS				
TENTS (3)	$6,284.91		1,308.20		
LABOR TO SET UP	$2,592.00				
LABOR TO REPAIR TENTS	$1,344.00				
LABOR TO BUILD SIDEWALLS	$432.00				
MATERIAL TO BUILD SIDEWALLS	$291.65				

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APPENDIX B
NCBC BAR CHARTS

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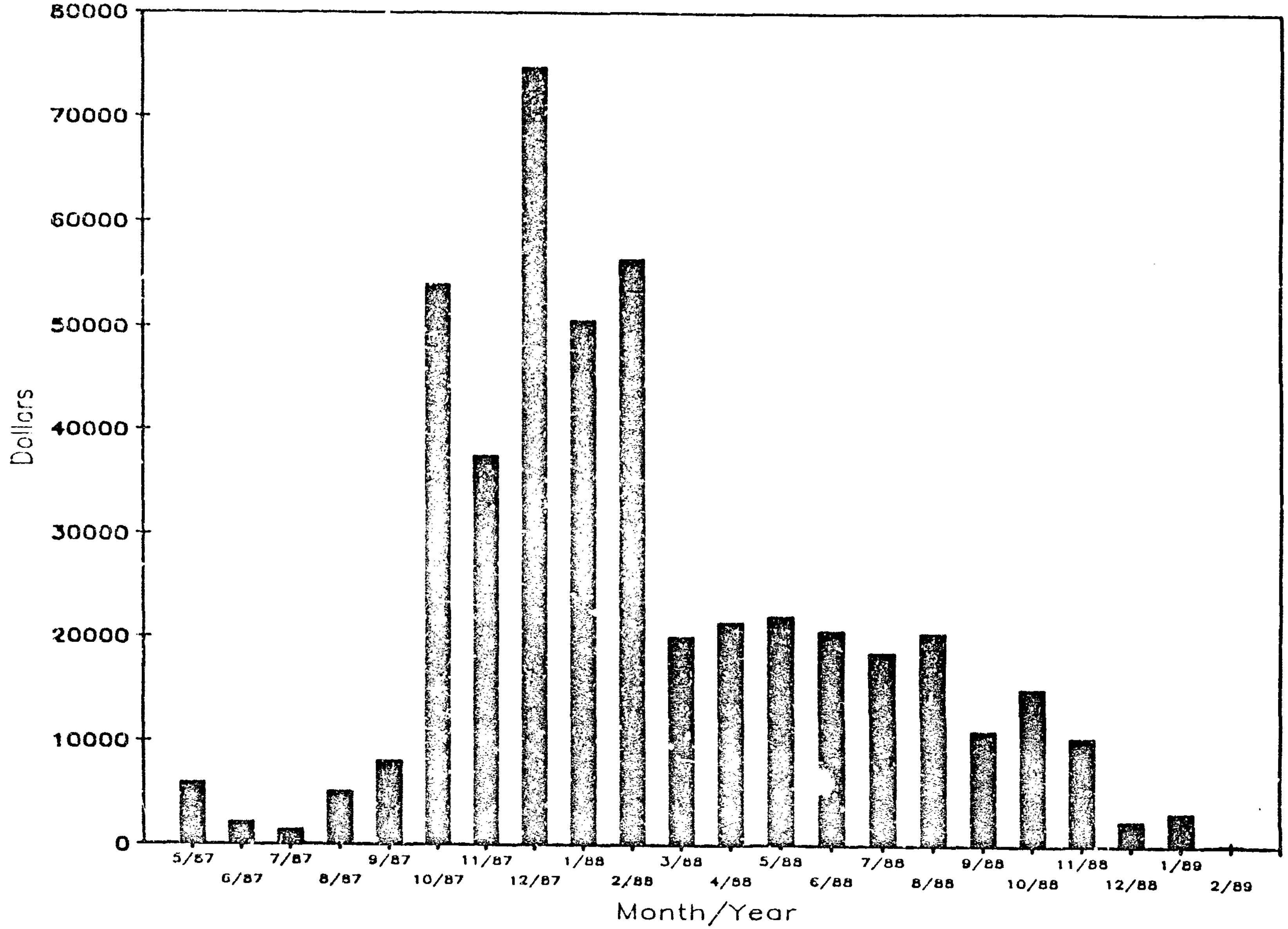

Figure B-1. Air Monitoring Costs

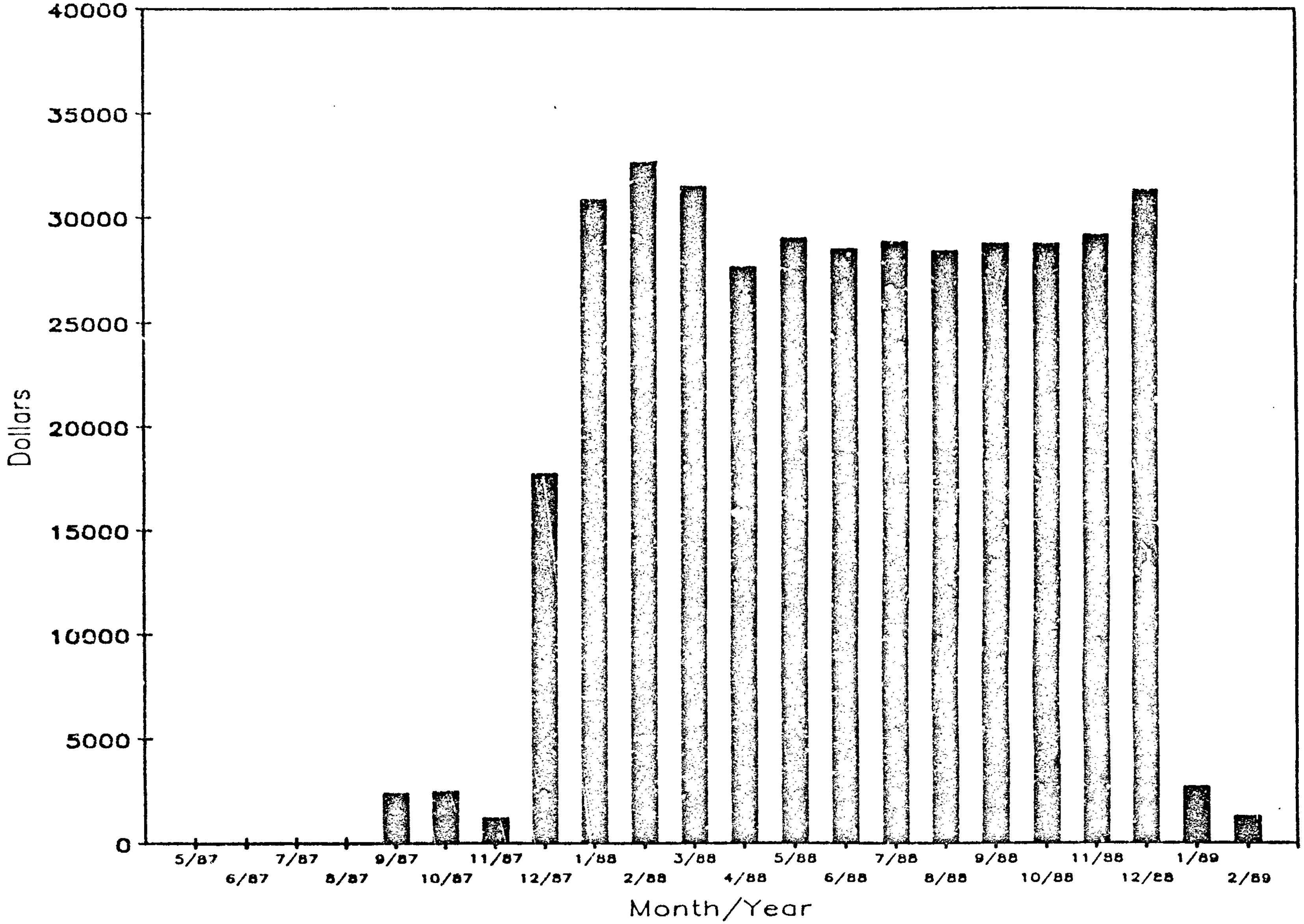

Figure B-2. Ash Storage Costs

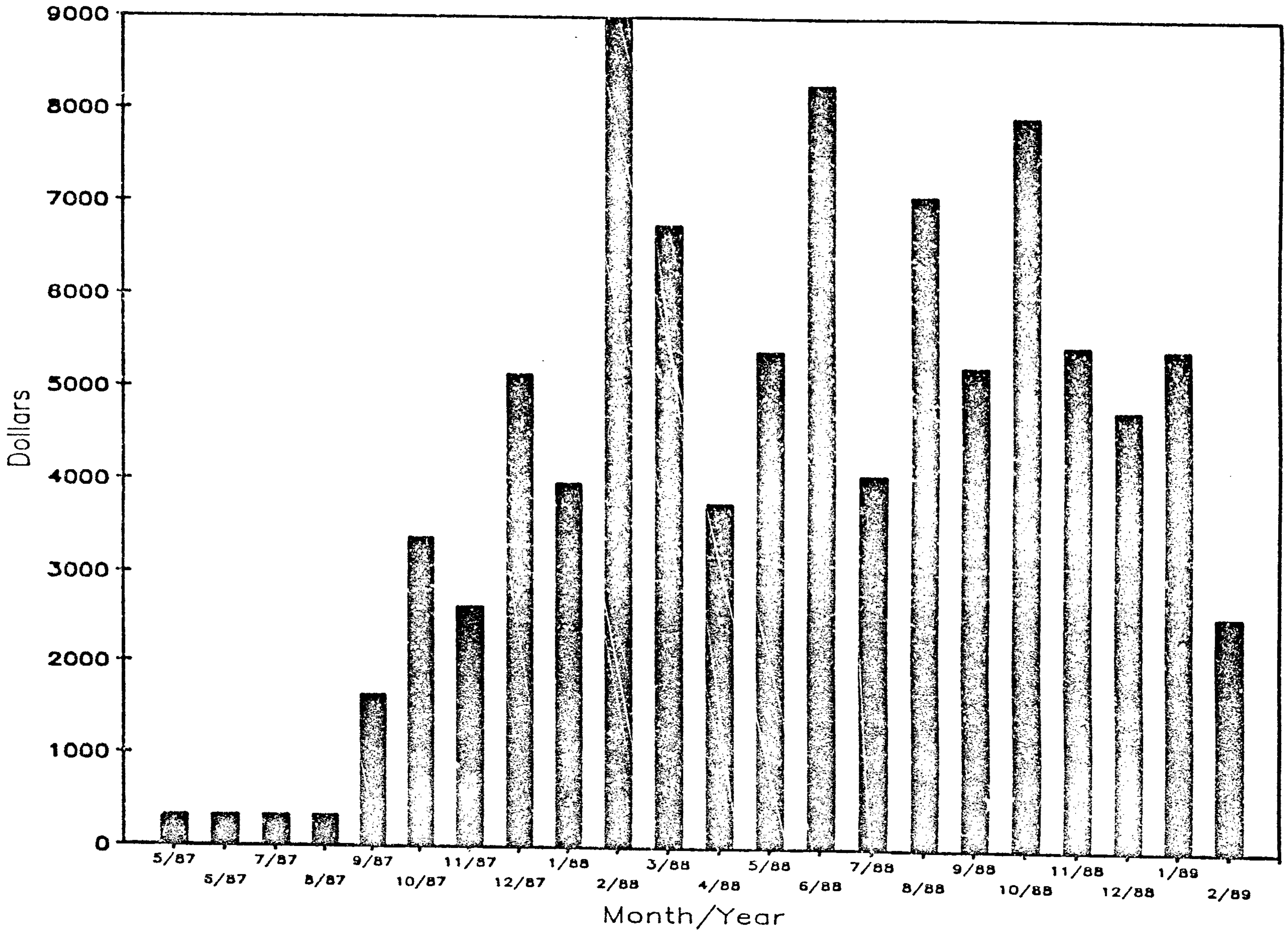

Figure B-3. Common Events Costs

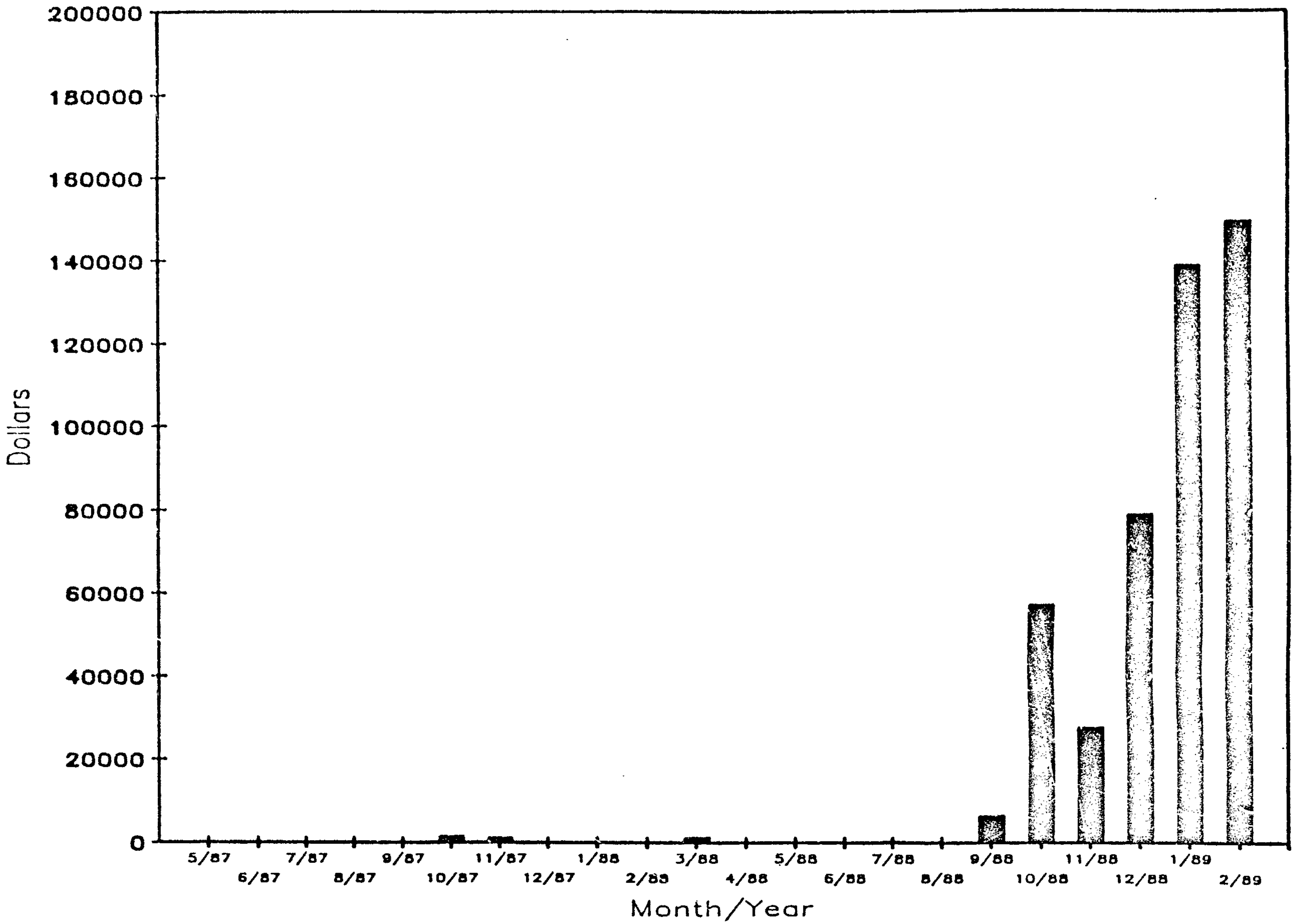

Figure B-4. Decontamination and Demobilization Costs

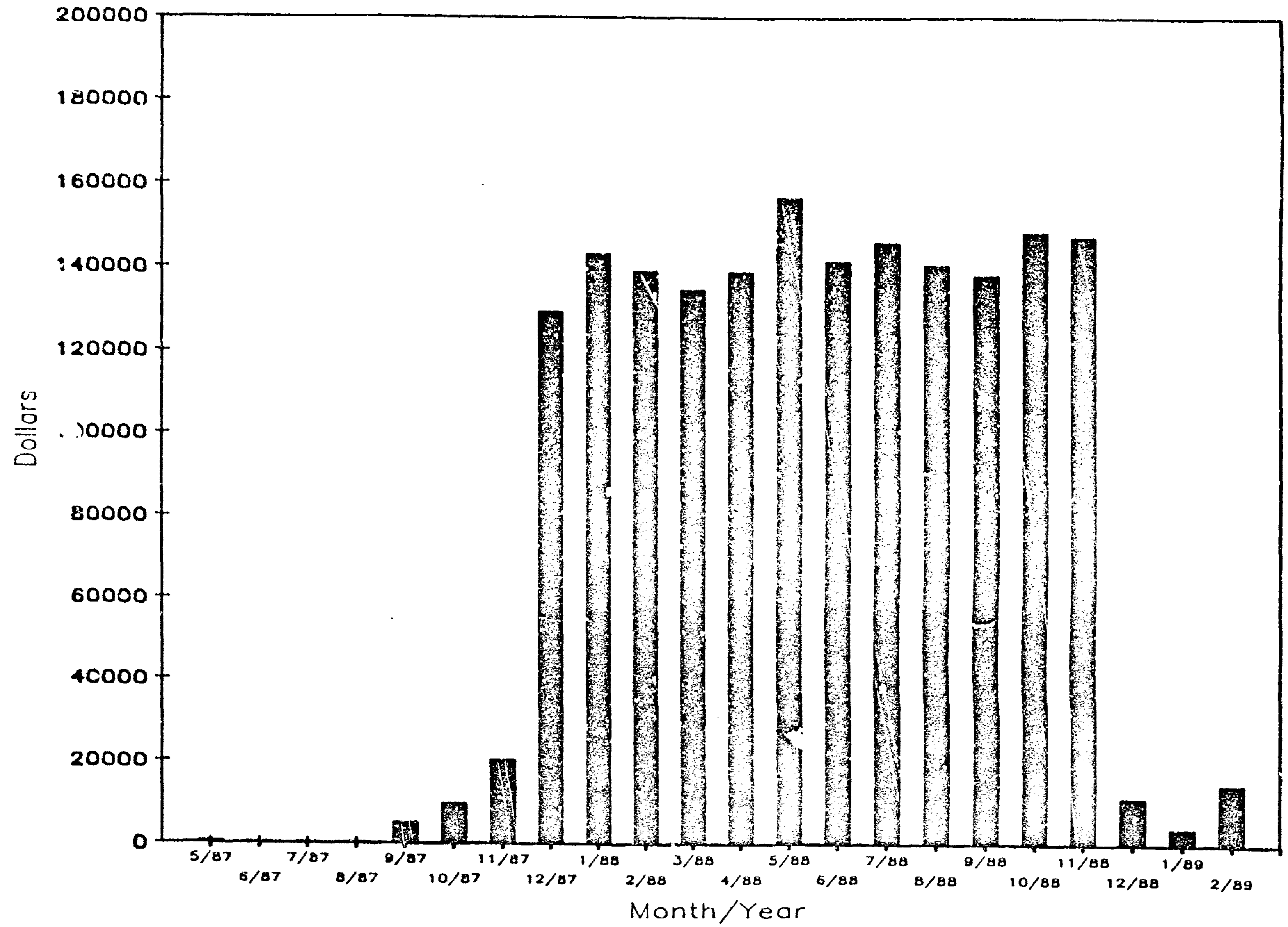

Figure B-5. Excavation Costs

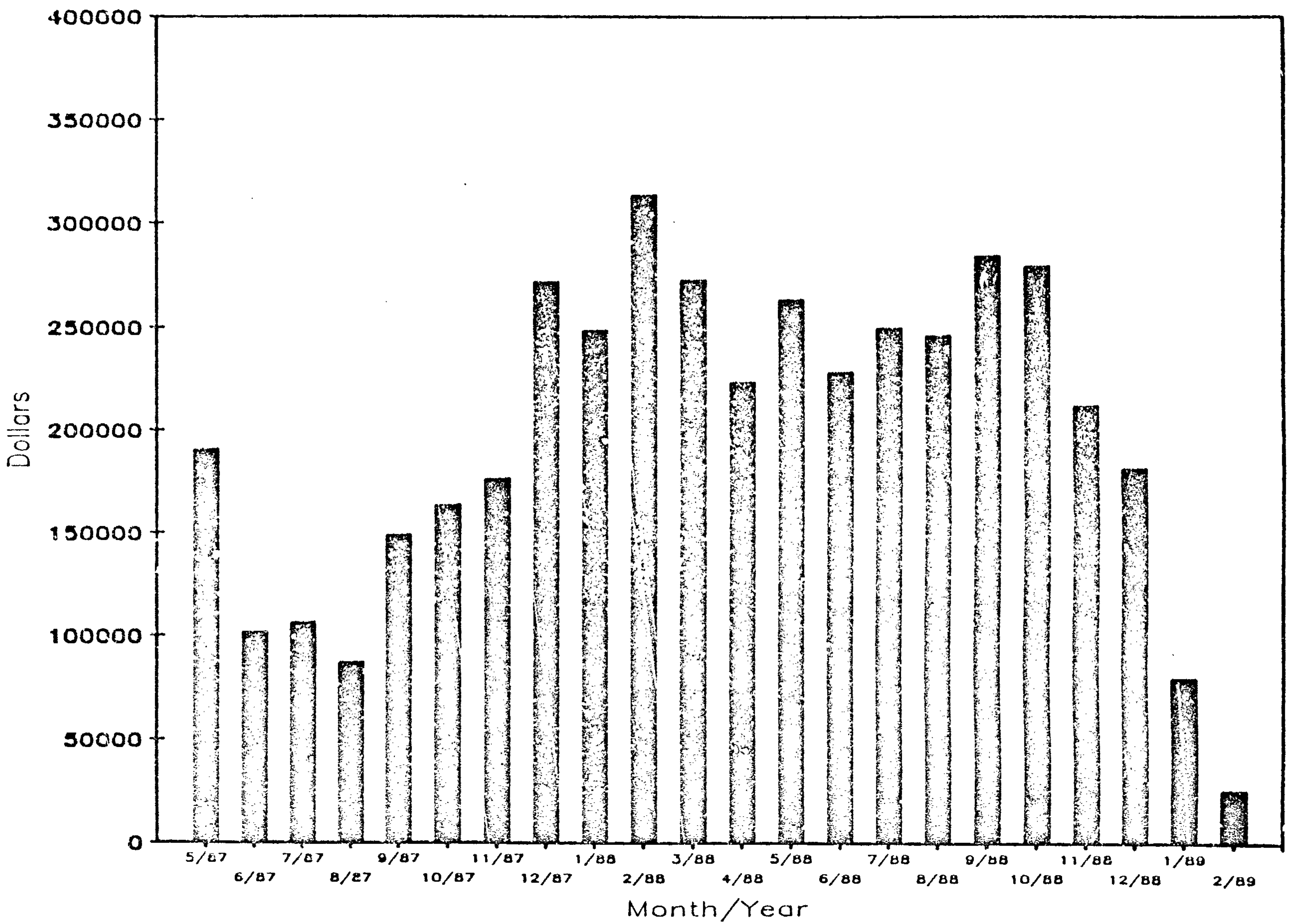

Figure B-6. Incinerations Operations Costs

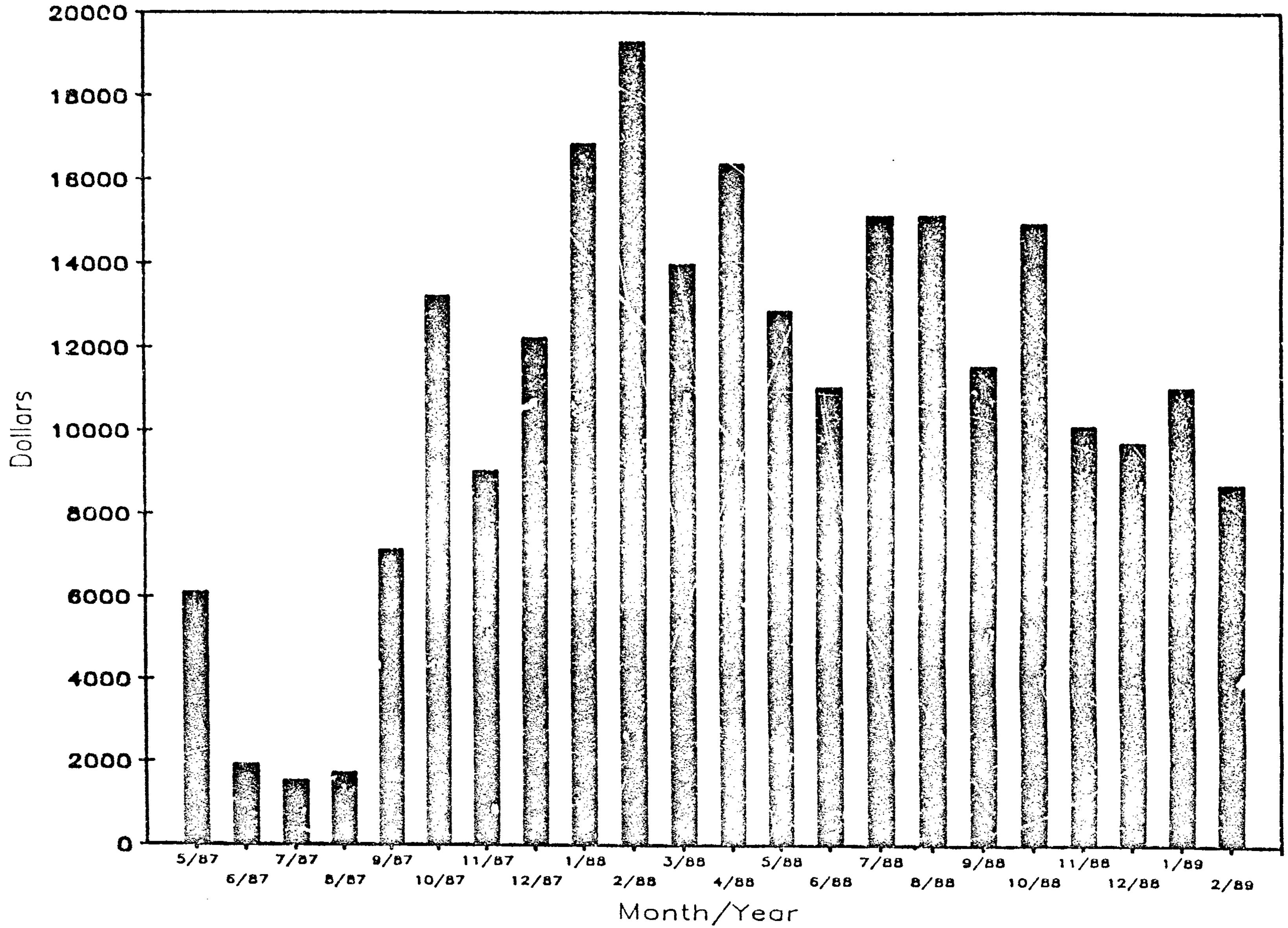

Figure B-7. Office/Site Services Costs

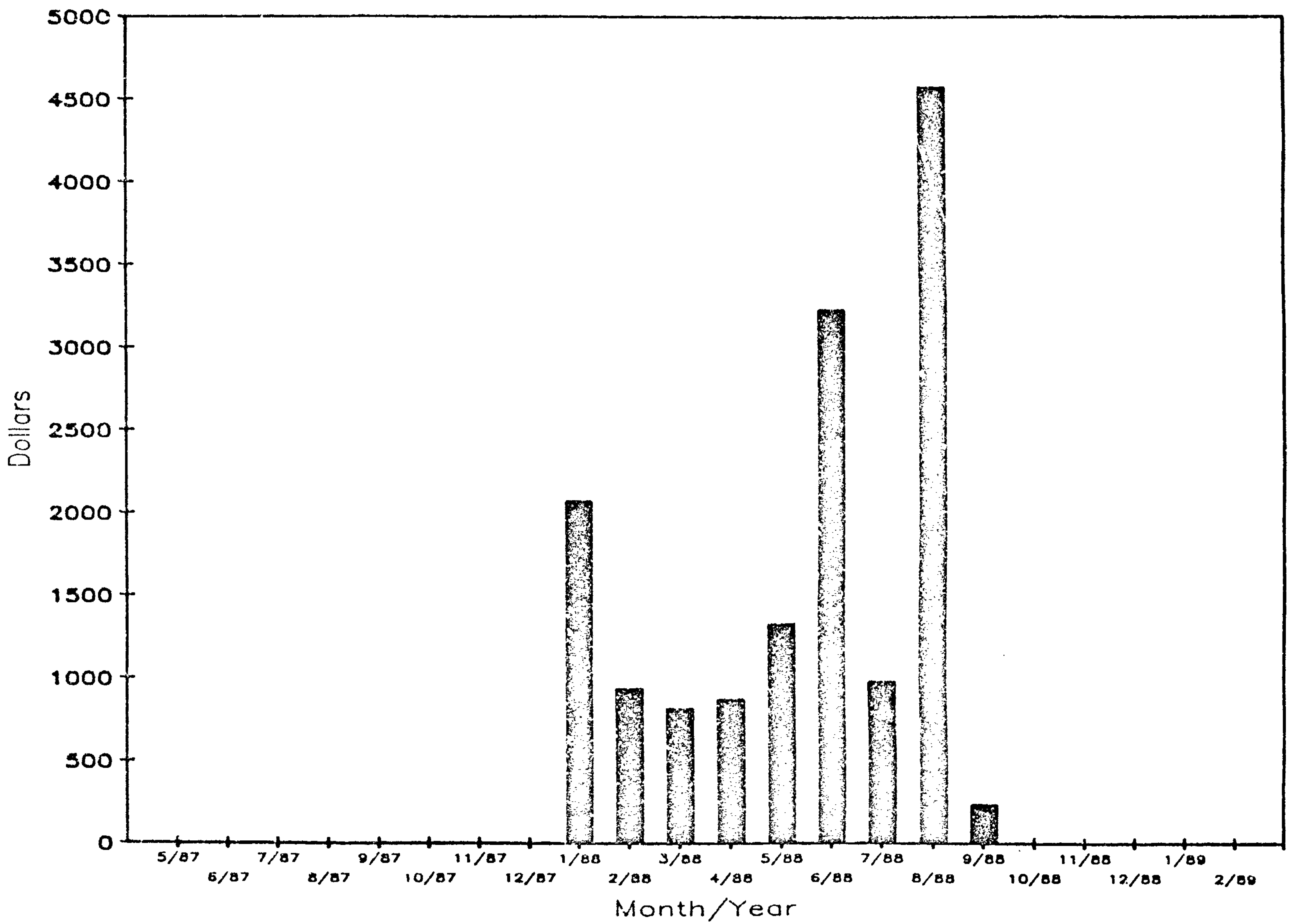

Figure B-8. Rock Crusher Costs

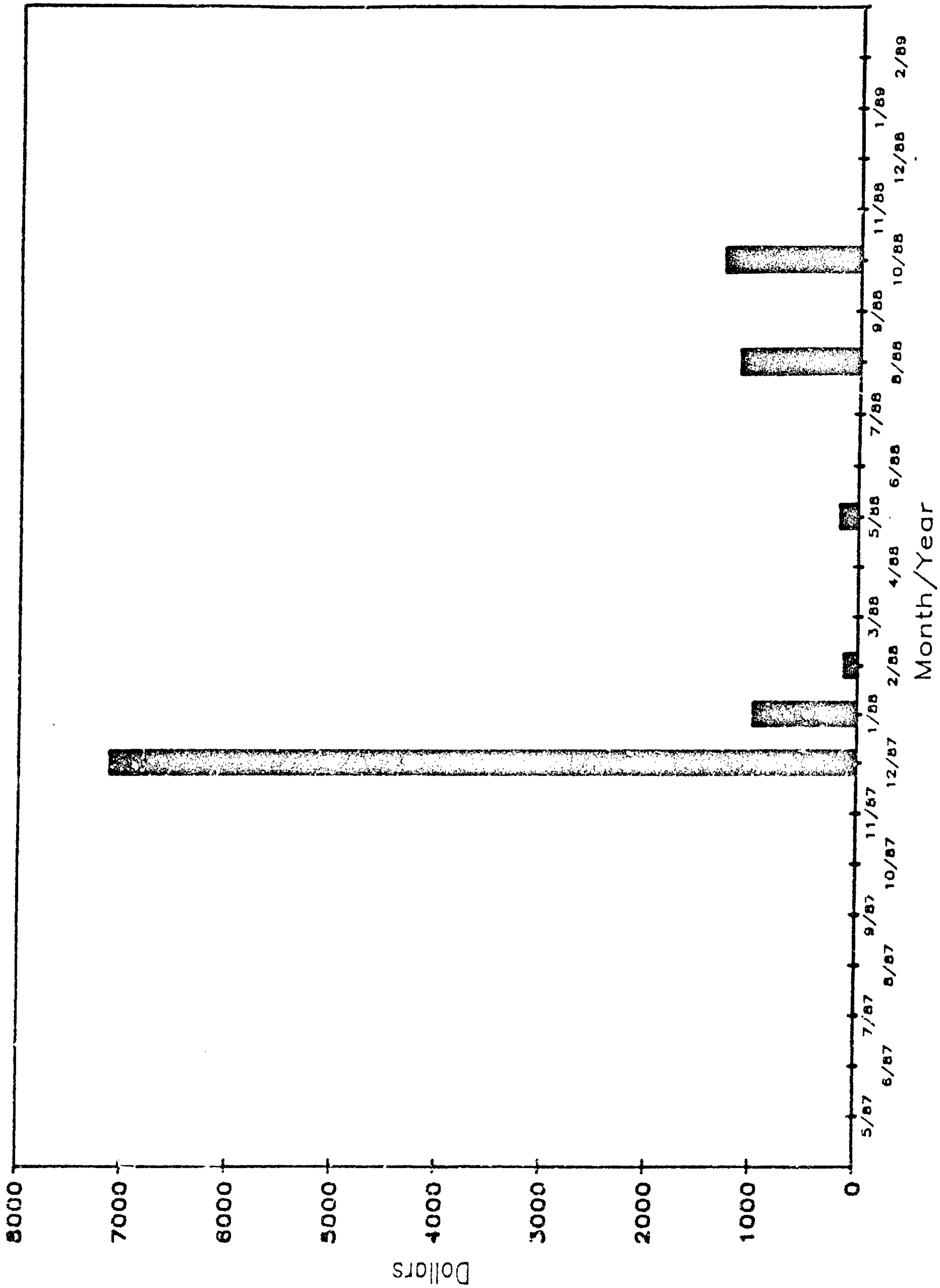

Figure B-9. Soil Storage Costs

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